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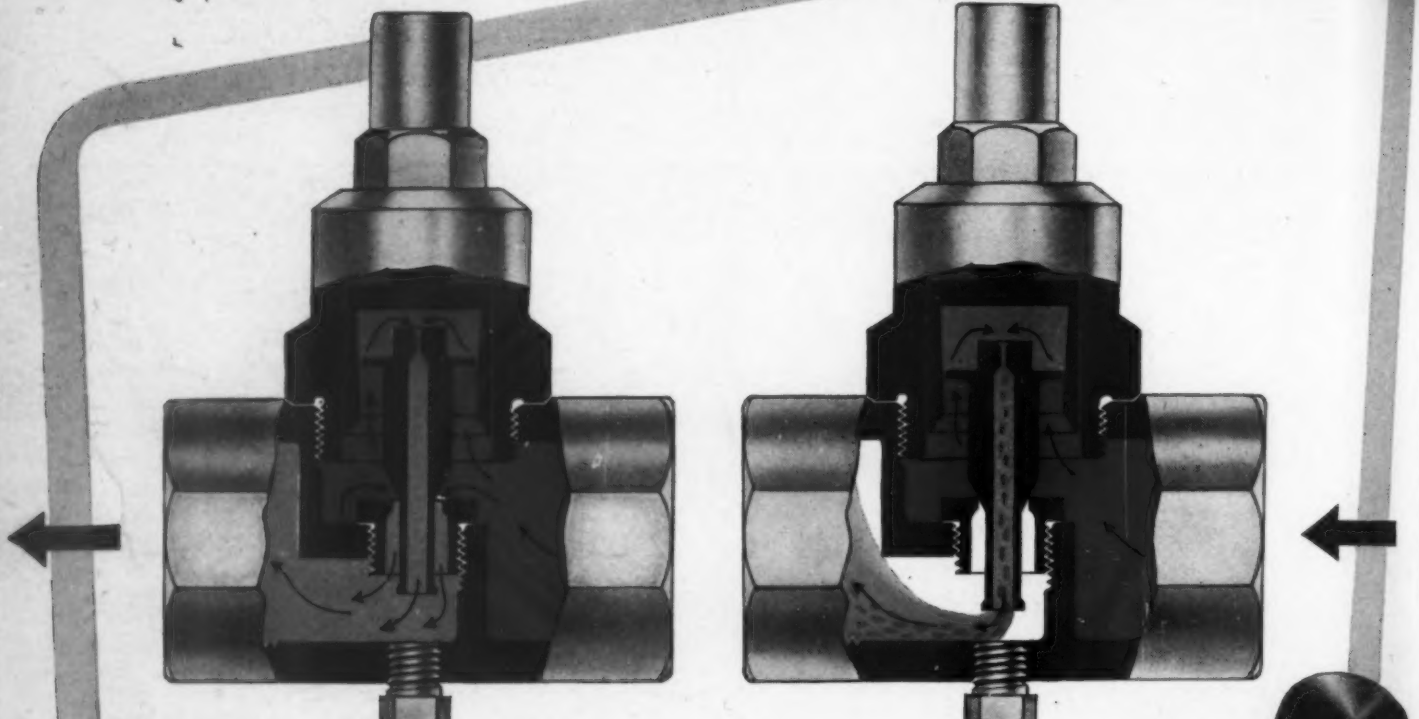

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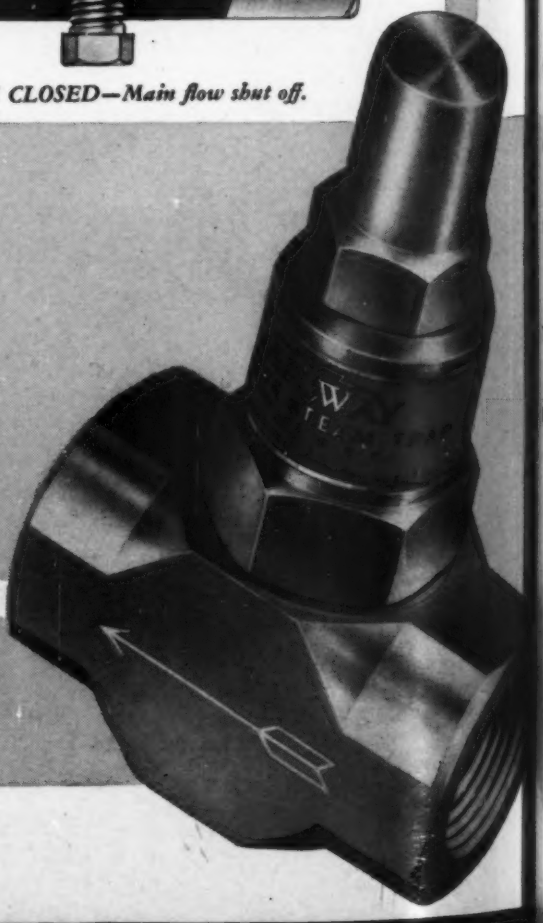

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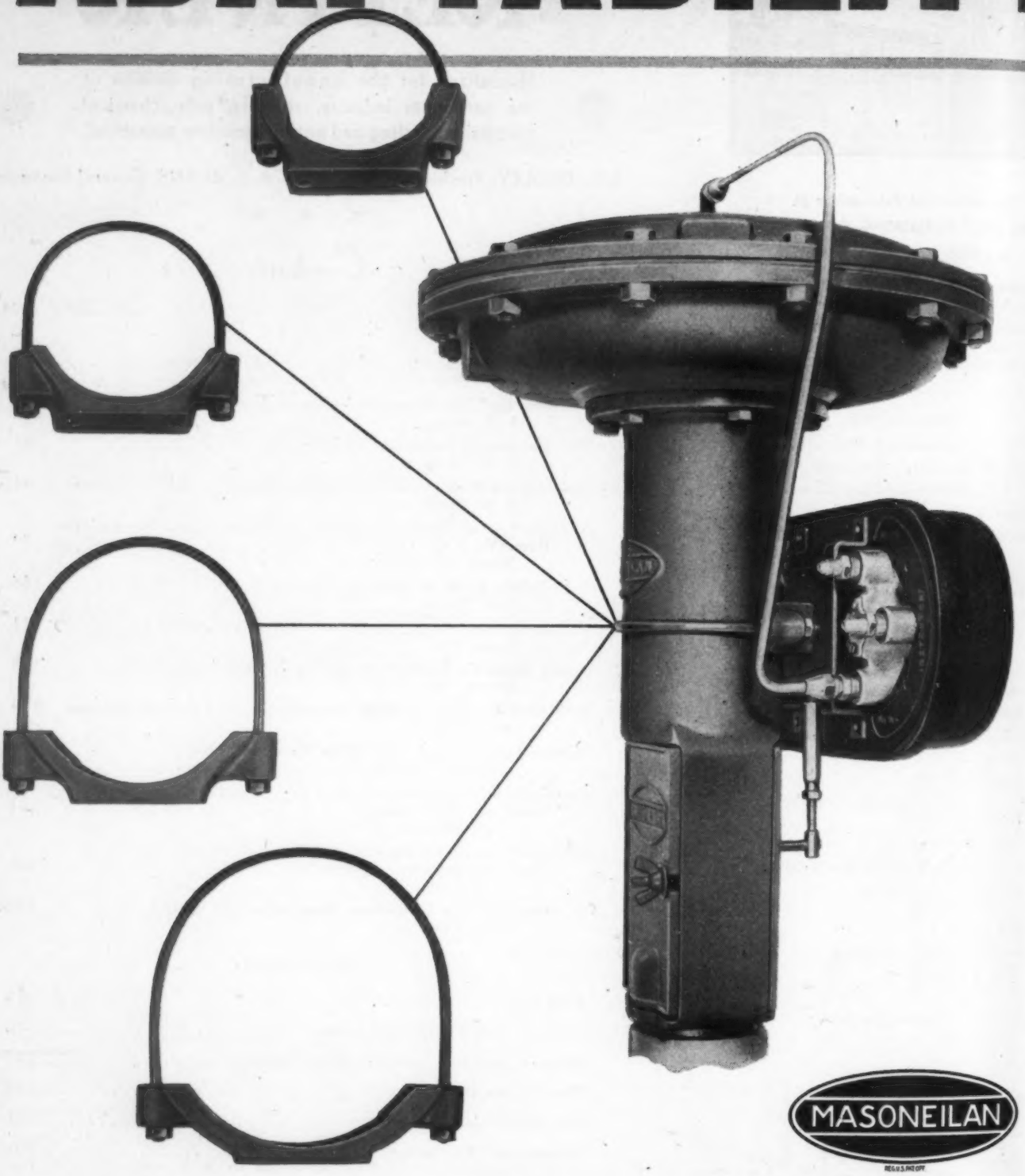

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VOLUME 26, NO. 10 OCTOBER, 1947

PETROLEUM
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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

WE WISH it had been possible a couple of weeks ago when PETROLEUM REFINER's editorial staff held one of its regular conferences for the entire family of subscribers to have sat in.

Cooperative Editorial Effort

The editors like to regard all subscribers as definitely a part of the staff. And we are coming to the opinion that many subscribers share something of the same view in that they seem to feel free to make suggestions and offer criticism, giving us their views on what we should do as well as what we have already done.

This, of course, is as it should be.

We were highly pleased a short time back when we undertook a survey of our readers, the point being "what subjects in the REFINER's entire field interests you?" The poll was a scientific one, the questionnaires being sent to relatively the same percentage of engineers, superintendents, executives, chemists, etc., as such classifications hold in our total subscription list. Names to the number equalling these percentage figures were chosen at random. Then the letters went out.

Your response was marvelous in more ways than one. First, something more than 53 percent took the trouble to fill in and return a rather detailed questionnaire. Then, the answers and comments showed real thinking and a genuine interest in the editorial content of the magazine—cooperative assistance to a degree that would warm any publisher's heart.

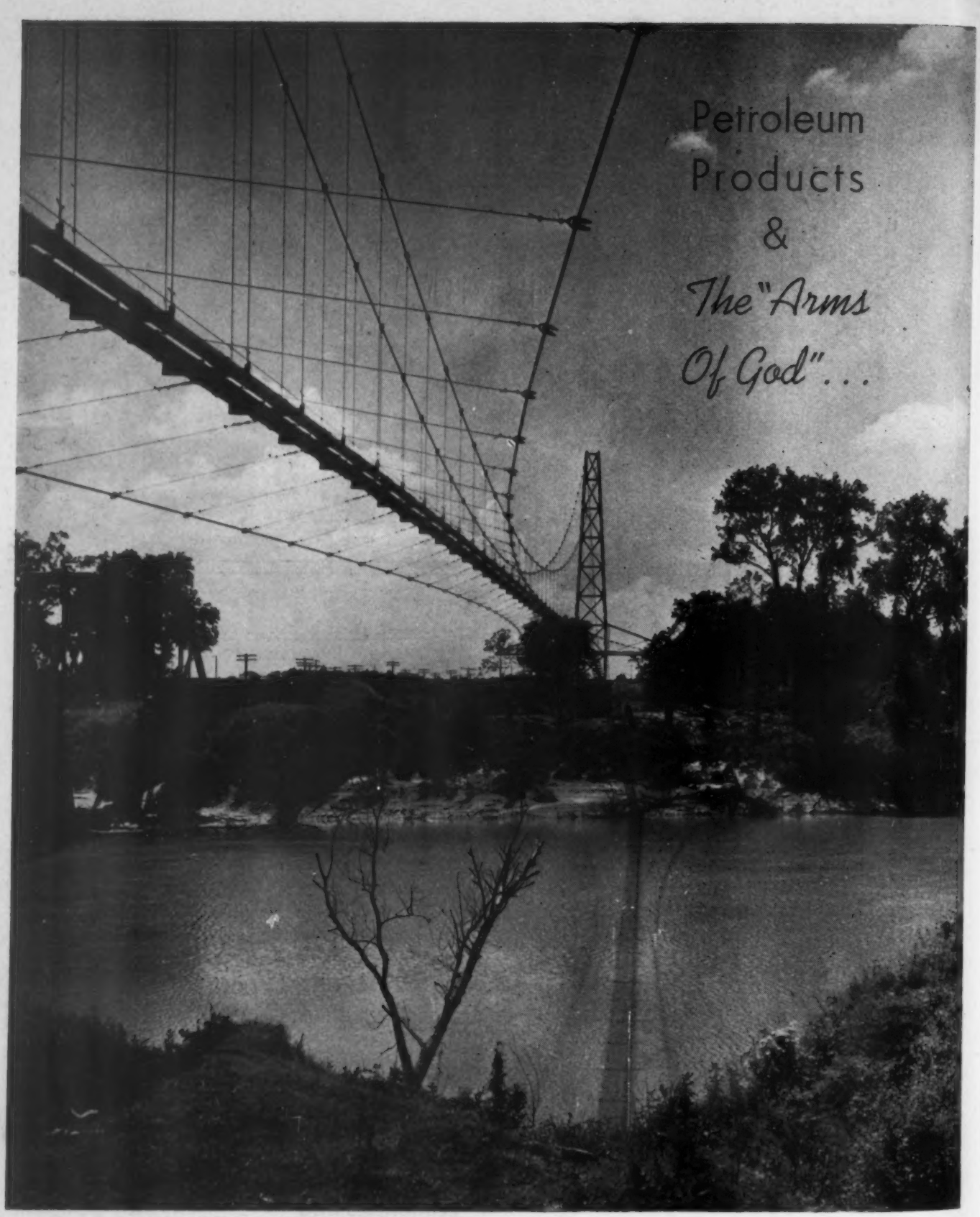
These answers and comments were thoroughly discussed, once in August and again late in September. In a large measure the weighted opinion of our subscribers has dictated the editorial program for the coming 12 months. And, we might add, a great program it is. Certainly it is much better than one that the editors could have developed alone.

So thanks for your help. Those readers who were not on the sample list, of course, have just as much voice as the others. Because postage is cheap and letters of criticism and suggestion are always welcome.

Our task is one of publishing just the sort of magazine that our readers desire. The recently solicited help, as pointed out, was most valuable. We like to think that you readers are planning with us and will, at all times, give us the benefit of your thinking.

A FEDERAL center of applied mathematics—the National Applied Mathematics Laboratories—has been added to the National Bureau of Standards, and represents the new concept of a centralized national calculation facility, equipped not only with high speed computation machinery, but able also to contribute to the development of such equipment. The development of high speed computation tools also carries with it a necessity for research and training in connection with the theory and disciplines needed for their most effective use. Organized to most effectively pursue their planned work, the division actually

Economies and Efficiencies



Legend says Spaniards fleeing Indians in Texas long ago were saved when a sudden flood in a stream they had just crossed stopped the savages. Thankfully, they named the protecting river the "Arms of God," in Spanish, "Brazos del Dios," now shortened to Brazos. Modern Brazos floods seem heedless of whose path they block, but flow of petroleum products in the 8-inch line above will never the interrupted. Brown & Root, Inc. have bridged the Brazos near Sealy with a 625-foot (between towers) pipe line crossing of their design, fabrication and erection. Take your river problems to Brown & Root, Inc.

BROWN & ROOT, INC.

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includes four separate laboratories: the Institute of Numerical Analysis; the Computation Laboratory; the Statistical Engineering Laboratory; and the Machine Development Laboratory.

From the standpoint of both government and private research and industrial processes, the final aim of the center is to provide the economies and introduce the efficiencies which are possible when relatively inexpensive calculating is substituted for costly trial-and-error experimentation.

More Problems

AUTOMOBILE engines now in development stages are expected to consume a third less gasoline and to be in general use by 1950, according to a recent statement by Charles F. Kettering, research consultant of General Motors Corporation. These engines are described as the natural outgrowth of gasoline and diesel engine development and have about the same overall dimensions as those in current use. In discussion concerning the prospects for rear-engine automobiles, Mr. Kettering said that he did not believe that they would be generally accepted, because "you can't change public habit."

Following this thought a little further, and not quoting Mr. Kettering, it seems likely that the new engines he predicts will have power outputs at least as high as those of current models, as it would be difficult to sell the general public on lower automobile performance levels than they now enjoy. Lower gasoline consumption for a given power output can be attained in two ways—by improvements in engine efficiency, and by increases in motor fuel octane levels. Past experience of our industry indicates that a considerable part of the problem will be met by increases in octane levels.

A lowering of gasoline consumption by a substantial number of automobiles will result in a lower gasoline demand, but this change seems likely to be numerical rather than actual insofar as its effect on refinery equipment investments or refinery runs to stills are concerned. Higher octane levels correspond to lessened gasoline yields from a given crude charge rate in existing process units. New processes and process schemes can be utilized to increase the yield of gasoline possible at any specified octane level, but this in turn calls for heavy investments in new construction and for the abandonment of some existing equipment.

Same Boat

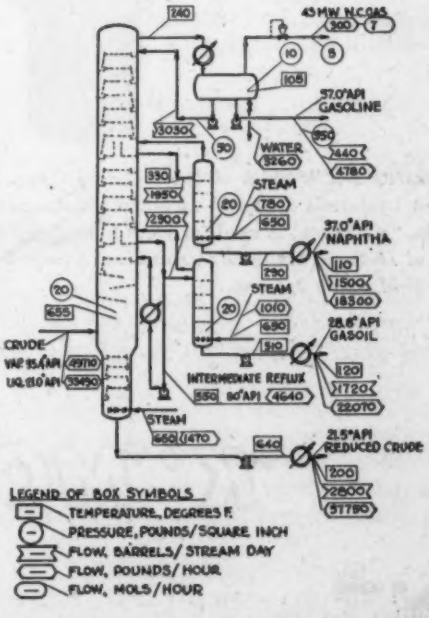
THE distorted picture of big versus little business, in which an effort is made to portray an opposition of interest between large and small enterprises, is basically false. We are not on opposite ends of a seesaw so that when one goes up, the other must go down. We are in the same boat. We will float or sink together. Without each other, big business and little business would go out of business.

EUGENE HOLMAN, *before Bradford District, Pennsylvania Oil Producers Association.*

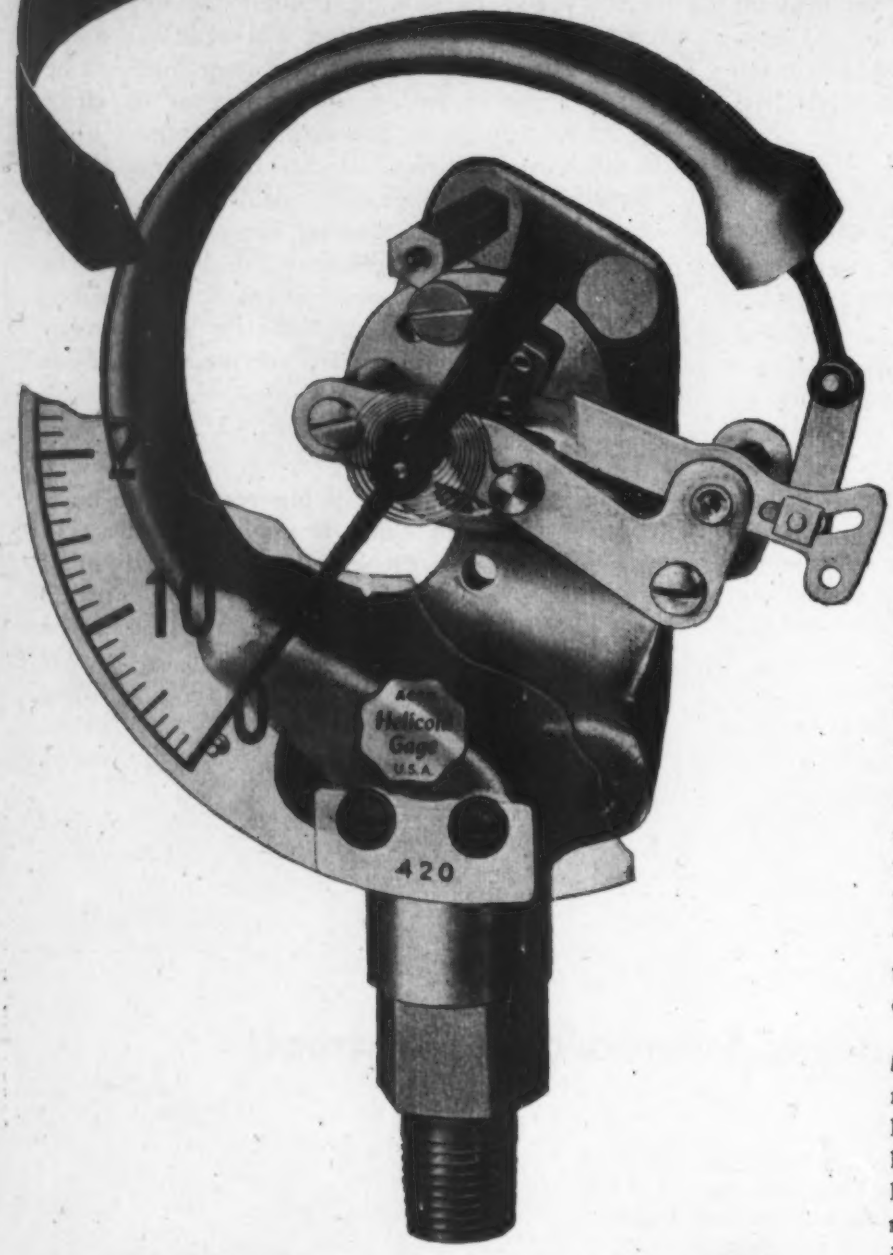
Refiner Adopts Standardized Symbols

IN THE September issue of PETROLEUM REFINER there appeared a brief article concerning the use of box symbols for the recording of data on plant flow diagrams. As explained in the article, one box shape is used for temperature data, another for pressure data, others for flow quantities, and so on. It was suggested that a set of these symbols be adopted as an industry standard, because of the obvious advantages they offer in recording operating data and in showing a large amount of information on complex flow diagrams while still preserving readability. Where such symbols are used a legend explaining their meaning must be given to avoid any possible confusion of terms.

As a step in the direction of standardization, flow diagrams used with articles appearing in PETROLEUM REFINER will employ, wherever practical, the set of symbols shown in the illustration below. This particular set of symbols has been used by several large companies and seems a likely choice for general application.



THIS TUBE SAVED 10 GAGES



WORKING MECHANISM of the Helicoid Gage. Because of its low hysteresis drift and excellent resistance to corrosive media, "K" Monel is used for Bourdon tubing. *Photo courtesy of Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.*

In the Permian Basin area field at Odessa, Texas, Gulf Oil Corporation had been having trouble.

Corrosive West Texas crudes limited pressure gage life to a maximum of five or six weeks.

The picture was pretty gloomy until April 5, 1946. Then Gulf installed an AMERICAN CHAIN & CABLE COMPANY Helicoid Gage with Bourdon tubing of "K"* Monel.

Weeks passed – fifty-five trouble-free weeks. Finally, on April 25, 1947, Gulf removed the gage. There was no question of failure; Gulf simply wanted to check its condition.

What did they find? No pit marks. No signs of corrosion. What's more, the gage tested accurate, so back into service it went. And it's *still* on the job!

"K" Monel is used for Bourdon tubing in this Helicoid Gage because of its unique combination of properties.

Besides being strong, rustproof and highly resistant to corrosive media, "K" Monel has the *extra* strength and hardness of heat-treated alloy steels. It has the low hysteresis needed to assure gage accuracy. Its retention of good fatigue strength is evident in the long life of equipment subject to alternating stresses in the presence of corrosives.

To Helicoid Gages – as to so many other types of oil field and refinery equipment –"K" Monel helps bring hairline accuracy . . . trouble-free performance . . . and extended life.

Remember "K" Monel whenever you have to fight corrosion by high-sulfur crudes at temperatures under 500° F.

*Reg. U. S. Pat. Off.

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The Mass Spectrometer and The Control Laboratory

DANIEL MILSOM, Laboratory Supervisor
Cities Service Refining Corporation, Tutwiler Refinery
Lake Charles, La.

THE mass spectrometer has been used to determine traces of various components, and identify impurities. Due to special techniques required for operating and maintenance of the spectrometer, it was considered to be impractical for routine work regardless of its possibilities. Recently the mass spectrometer has been used by several research laboratories to determine the composition of light hydrocarbons. As a result of these investigations, the instrument has been adapted to routine analysis. This article contains an example of the mass spectrometer being applied to routine analysis of light hydrocarbons resulting from modern refining operations. In order that the theory of the mass spectrometer can be better appreciated, the theory of operation is explained in a simplified manner. Data on the efficiency, reproducibility and accuracy of the instrument also are included.

IN THE course of development of the petroleum industry, it has been necessary for the laboratory to keep pace with operations by analyzing the complicated mixtures produced by cracking and alkylating petroleum stocks. This is particularly true in the case of light hydrocarbon analysis. In the early days of casinghead gas, charcoal and compression tests were sufficient for arriving at an acceptable analysis. However, with the advance of petroleum technology, this method of analysis no longer gave sufficient information and it became necessary to turn to low temperature fractionation to separate the hydrocarbon mixtures according to the number and arrangement of the carbon atoms. With the advent of cracking petroleum, the complexity of the gas mixtures increased. Due to the difficulty encountered in separating hydrocarbons with only two or three degrees difference in boiling points, distillation analysis was supplemented with chemical analysis of the fractions to determine the olefinic content of the hydrocarbon gases. Most methods of differentiation between isomers of olefins are empirical and require closely controlled and reproducible conditions.

Since the physical and chemical properties of isomeric compounds are very similar and since the analysis of these compounds by existing methods is time consuming, investigators began to explore the possibility of other physical properties for the analysis of light hydrocarbon mixtures.

The optical properties of hydrocarbons in the near infra-red region of the spectrum were utilized to develop new procedures for identifying and evaluating hydrocarbons. Although these procedures are applicable to all hydrocarbons (liquid or vapor), the difficulty of finding appropriate spectral positions for each component and the calculations involved probably will limit these methods to mixtures of less than eight or ten compounds.

Calibration of Instrument

To utilize infra-red methods of analysis to the best advantage, it is desirable to know the qualitative composition of the sample. The instrument can then be calibrated for various combinations or series of hydrocarbons and the appropriate calibration curves used to determine the percentages of the different components present in the mixture. Since a large amount of time is necessary to calibrate the infra-red instrument, this method is most valuable for a large number of samples of similar composition.

An instrument which has recently been adopted by the petroleum industry and which is more generally adaptable to the type of mixture received for analysis than any other instrument is the mass spectrometer. A few years ago, when the mass spectrometer was first introduced to the industry, its complicated electronic circuits and maze of vacuum tubes made it a machine of deep mystery. Even today the average analytical chemist might not be able to present a very concise explanation of the theory of the mass spectrometer. However, the operators of these instruments appreciate their accuracy and versatility and the short analysis time makes it very desirable.

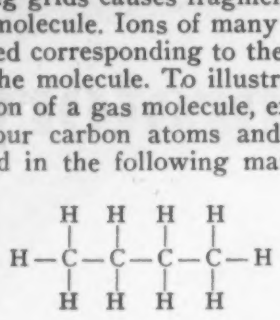
The application of the mass spectrometer to gas analysis is not new. For years, many universities have used it from time to time for a rapid check on the impurities in gas samples. A typical example is the discovery of heavy hydrogen—"heavy water"—in 1932 by Professor H. C. Urey of Columbia University.

During the early period of development of the instrument no interest was shown in the mass spectrometer by the petroleum industry. In the latter '30's, several people began to realize that the instrument was capable of being perfected to the point where it could be operated for routine control analysis. Much of the research of the instrument was directed toward a mathematical method for differentiating between the isotopes of hydrocarbon gases.

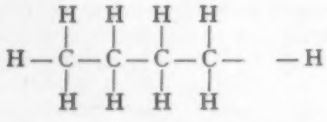
General Theory

The mass spectrometer is essentially a high vacuum tube in which the gas to be analyzed is admitted at

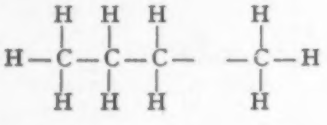
a pressure of the order of 10^{-4} mm of mercury. The bombardment of the molecules of the gas with electrons of controlled energy from a thermionic filament and accelerating grids causes fragmentation and ionization of the molecule. Ions of many different structures are formed corresponding to the various modes of fracturing the molecule. To illustrate the process of fragmentation of a gas molecule, examine a molecule having four carbon atoms and ten hydrogen atoms arranged in the following manner:



When the electron bullets strike the target, the molecule disintegrates according to a definite scheme. Part of the molecules have only one electron removed and are thus positively charged molecules. Simultaneously, some of the molecules have one hydrogen atom removed, leaving the balance of the molecule with a positive electric charge. The gas molecule then looks like this:



This process is continued with two hydrogens, three hydrogens, and a carbon and three hydrogens, at which time the gas molecules can be pictured by the following scheme:



The scission of the gas molecule continues in this manner. Rather simultaneous products are obtained for each possible point, where the different carbon and hydrogen atoms are bound together.

A graphical portrayal of this scission and the relative ion abundance is illustrated by Figure 2.

The ions so formed are then drawn out of the ionizing chamber by an applied electric field and are caused to move through a combination of electric and magnetic fields designed so as to isolate the ions according to their mass to charge ratio.

The mass spectrometer, unlike an optical spectrometer which separates a light beam into its component parts, separates a beam of molecular ions into its component masses. The presence and relative abundance at each mass is recorded, hence the name spectrometer. Like any moving charged particle, the ion is surrounded by a magnetic field, which when passing through another magnetic field is deflected from a straight line to a curved path. If the initial velocity and the magnetic field strength are constant, the radius of curvature of the ions will depend upon the mass of the ion. The radii of curvature of the ions increases with increasing molecular weight (Figure 1). If, then, the accelerating voltage is varied from high voltage to low, the ions will sweep across the exit slit from low to high molecular weight.

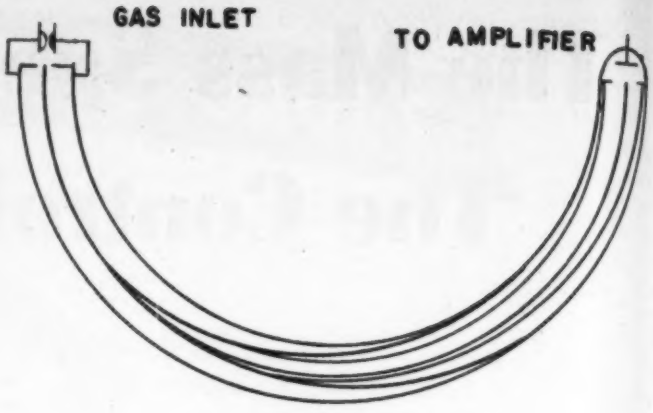


FIGURE 1
Magnetic Field Perpendicular to Plane of Paper

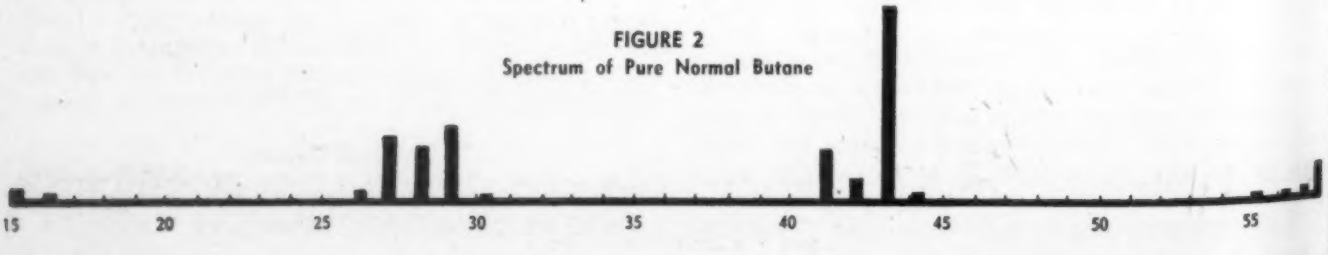
In practice, the energy in the bombarding electrons is usually made sufficiently high to break the molecules into charged fragments. This feature enables substances of the same molecular weight but of different atomic arrangement to be distinguished from each other. The mass spectrum depends not only upon the structure of the molecules but also upon the arrangement of the atoms within the molecule. For example, the mass spectrum for *n*-butane and isobutane have peaks at the same masses but their relative heights are different. See Figures 2 and 3. It is the dependence of the mass spectrum upon the structure of the molecule that enables the isomers of a compound to be determined separately.

If the mass spectrum of an unknown mixture is obtained employing a suitable technique, it will be a composite mass spectrum of all the components of the mixture. By comparison with the mass spectrum of pure compounds and using a suitable mathematical technique, the unknown mass spectrum can be unraveled and the kinds as well as the amounts of the different components can be determined. These relative peak heights are graphically portrayed in Figures 2, 3, 4, 5 and 6 and the contribution of each compound to the different peaks is shown (Figure 7 and Table 1).

Scope of the Instrument

Any light hydrocarbon gas mixture containing any or all of the components from methane through pentanes and including the non-condensable gases hydro-

FIGURE 2
Spectrum of Pure Normal Butane



gen, nitrogen, oxygen and carbon monoxide can be analyzed on the mass spectrometer provided pure gases are obtainable for calibration. Traces of C_6 hydrocarbons (0.1 to 3 percent) can be tolerated if an average pattern can be obtained. Any samples containing larger amounts of C_6 hydrocarbons are fractionated in a low temperature column and the overhead gas from the distillation is analyzed on the mass spectrometer. Nitrogen, oxygen and hydrogen can be accurately determined on the mass spectrometer. Carbon monoxide and carbon dioxide interfere with some hydrocarbons. In practice, the carbon dioxide is scrubbed from the sample and determined separately and carbon monoxide is determined on the mass spectrometer even though its accuracy is not as great as the other non-condensable gases.

It is possible with the mass spectrometer to analyze heavier hydrocarbons. Analysis of hydrocarbons with as many as eight carbon atoms has been deter-

Table 1.

Contribution of Each Component to Total Peak Height

	C_1	C_2	C_3	iC_4	nC_4
15	1.93	0.25	0.36	3.35	0.31
16	2.35	0.01	0.01	0.20	0.01
26	....	1.40	0.45	0.98	0.28
27	....	2.05	2.09	12.70	1.86
28	....	6.44	3.10	1.54	1.67
29	....	1.37	5.23	3.03	2.24
30	....	1.57	0.11	0.09	0.05
41	....	....	0.73	19.61	1.56
42	....	....	0.35	17.51	0.70
43	....	....	1.33	54.35	5.83
44	....	....	1.57	1.82	0.20
55	....	....	....	0.25	0.06
56	....	....	....	0.21	0.05
57	....	....	....	1.79	0.16
58	....	....	....	1.57	0.78
Percent	30	20	20	20	10

FIGURE 3

Spectrum of Pure Iso-Butane

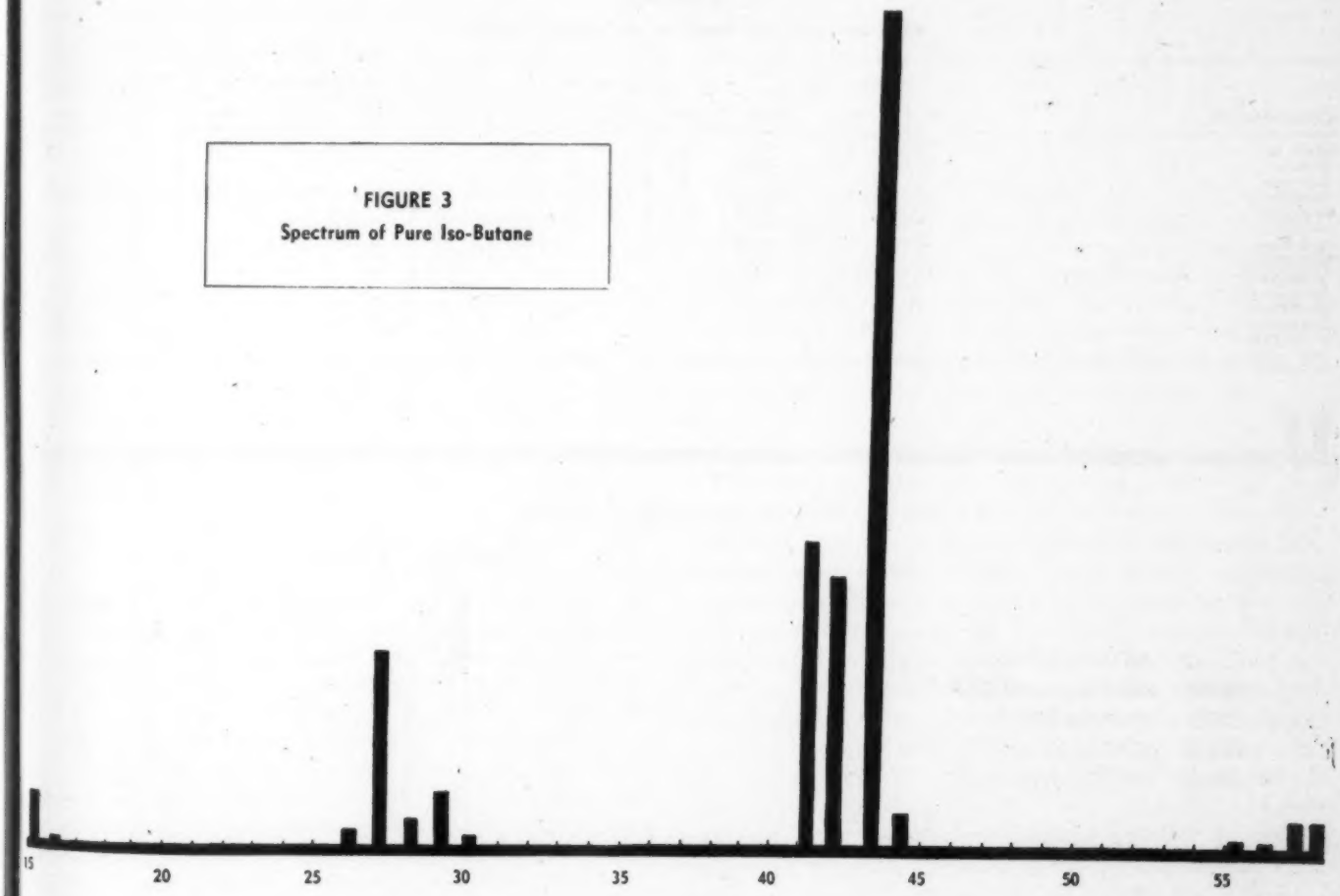


Figure 4. Spectrum of Pure Propane

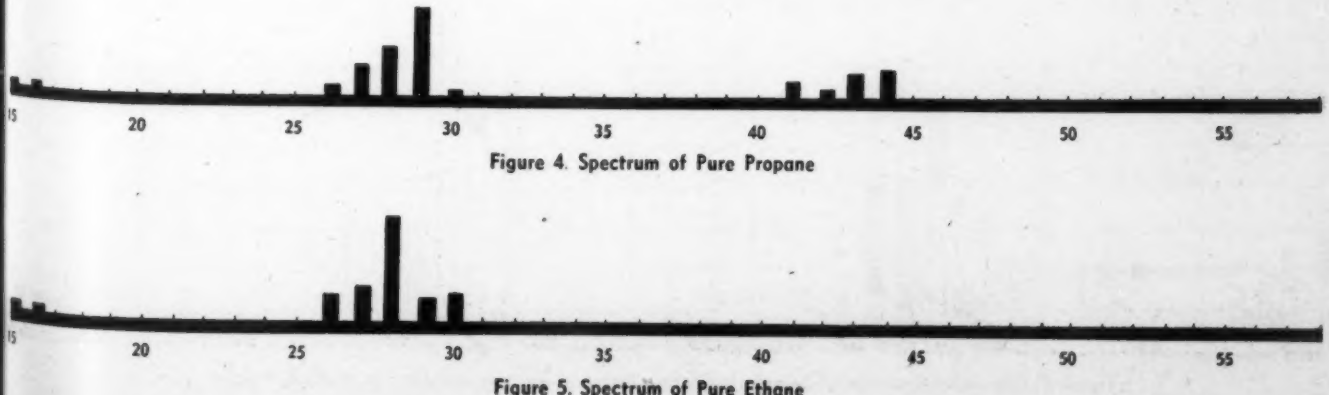


Figure 5. Spectrum of Pure Ethane

TABLE 2

Comparison Analysis of Various Plant Samples with Mass Spectrometer and Low Temperature Distillations

SAMPLE	Depropaniser		Depropaniser		Propane-Propylene		Debutaniser		Debutaniser	
	M.S.	Ped.	M.S.	Ped.	M.S.	Ped.	M.S.	Ped.	M.S.	Ped.
Methane	0.2	....	0.1	....	....	....	....	....	....	....
Ethane	7.6	7.1	9.7	9.3	4.6	4.8	....	....	....	....
Ethylene	1.5	....	....	....	0.8	....	....	....	....	....
Propane	87.4	89.2	86.5	88.8	31.3	95.2	0.5	....	0.7	....
Propylene	....	0.2	....	0.9	60.7	....	0.7	....	0.1	....
Isobutane	3.3	3.5	3.5	1.0	2.8	....	29.4	32.9	31.5	32.1
N-butane	....	....	....	....	....	....	5.6	5.2	8.8	9.1
Isobutylene	....	....	0.2	....	....	....	19.4	17.5	20.8	24.3
N-butylene	....	....	....	....	....	....	39.7	42.3	36.0	32.0
Isopentane	....	....	....	....	....	....	0.7	2.1	1.0	2.5
Pentenes	....	....	....	....	....	....	1.0	....	1.1	....

mined with reasonable accuracy. However, in order to analyze samples of this type, the number of compounds in the mixture should be limited to seven or eight and it is then necessary to enter the sample to the gas inlet system at low pressure so that the hydrocarbons are not absorbed in the stopcock grease.

Accuracy

Experience obtained thus far indicates that the mass spectrometer is as accurate as the most carefully operated low temperature distillation column and not nearly so time consuming. Table 2 presents the comparison between analyses from low temperature distillations operated for routine control and mass spectrometer analysis of some typical refinery gases. Table 3 lists the mass spectrometer analysis of synthetic blends. It will be noted from this table that the accuracy of the individual butylenes is not comparable to the accuracy of the other components. This loss in accuracy can be attributed to the similarity

TABLE 3

Mass Spectrometer Analyses of Synthetic Mixtures

COMPONENT	Synthetic No. 1			Synthetic No. 2			Synthetic No. 3		Synthetic No. 4		Synthetic No. 5	
	M.S.	M.S.	Syn.	M.S.	M.S.	Syn.	M.S.	Syn.	M.S.	Syn.	M.S.	Syn.
Methane	14.02	13.95	14.04	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ethane	20.75	20.34	20.31	5.1	5.1	5.3	.....	.....	.....	.....	.....	.....
Ethylene	.....	.....	.....	3.6	3.7	3.6	.....	.....	.....	.....	.....	.....
Propane	20.02	20.23	20.31	28.4	28.5	28.6	.....	.....	.....	.....	6.7	6.6
Propylene	10.05	10.34	10.23	60.2	60.3	60.1	.....	.....	.....	.....	.....	.....
Isobutane	10.33	9.92	10.05	2.7	2.4	2.4	5.2	5.2	3.9	3.3	41.4	40.8
N-Butane	7.89	8.25	8.02	.....	.....	.....	4.8	4.9	13.8	13.9	5.7	5.3
Isobutylene	6.15	5.81	6.66	.....	.....	.....	47.1	46.6	8.1	7.1	4.2	5.2
N-Butylene	10.79	11.16	10.38	.....	.....	.....	42.9	43.3	56.1	57.4	32.8	32.4
Total Butylenes	16.94	16.97	17.04	.....	.....	.....	90.0	89.9	64.2	64.5	37.0	37.6
Butadiene	.....	.....	.....	.....	.....	.....	.....	.....	18.1	18.3	.....	.....
Isopentane	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.5	4.8
N-Pentane	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.7	4.9

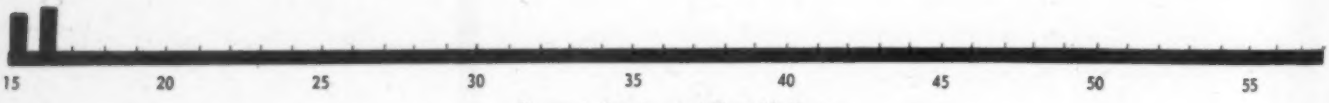


Figure 6. Spectrum of Pure Methane

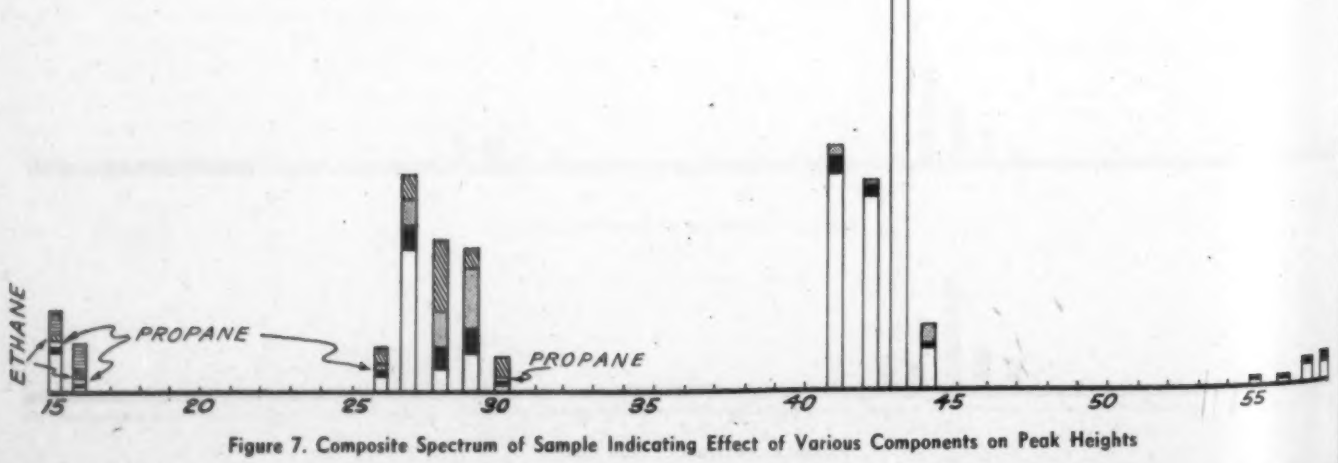


Figure 7. Composite Spectrum of Sample Indicating Effect of Various Components on Peak Heights

TABLE 4

Data on Reproducibility of Mass Spectrometer Analyses on Plant Streams

Date	Methane	Ethane	Ethylene	Propane	Propylene	I-butane	N-butane	I-butylene	N-butylene	Pentanes	Pentenes	C_6+	CO_2	O_2	CO	H_2	N_2
UNIT GAS																	
12/11	8.2	3.4	4.4	5.7	16.7	13.2	1.9	11.0	....	5.4	2.3	0.4	1.5	0.2	1.2	3.5	21.0
12/20	8.0	3.1	3.6	6.0	16.3	13.7	2.2	11.4	....	6.1	2.4	0.4	1.5	0.1	0.8	3.6	20.8
12/30	8.0	3.3	4.0	6.1	16.6	13.7	2.2	12.0	....	5.4	1.9	0.4	1.5	0.1	1.0	3.6	20.2
1/ 6	8.0	3.1	4.2	5.9	16.7	13.6	2.5	11.7	....	5.2	1.8	0.3	1.5	0.1	1.5	3.8	20.1
1/ 9	7.8	3.0	3.6	6.0	16.8	13.7	2.4	11.7	....	5.2	1.8	0.3	1.5	0.3	1.5	3.8	20.6
1/19	8.2	3.3	4.3	6.1	16.4	13.2	2.4	11.8	....	6.1	2.0	0.5	1.5	0.1	1.1	3.3	19.7
2/ 6	8.0	3.3	3.7	6.0	16.5	13.4	2.2	11.2	....	5.6	2.1	0.3	1.5	0.2	1.5	3.5	21.0
PROPANE-PROPYLENE																	
11/ 9	0.3	5.2	1.8	27.5	61.4	2.3	....	1.5	....	....	....	....	....	....	....	....	....
11/14	0.2	5.2	1.9	27.7	61.7	2.1	....	1.2	....	....	....	....	....	....	....	....	....
11/15	0.2	4.7	2.0	27.9	61.9	2.2	....	1.1	....	....	....	....	....	....	....	....	....
11/27	0.2	5.2	2.0	27.3	61.9	2.2	....	1.2	....	....	....	....	....	....	....	....	....
12/12	0.2	5.1	2.1	28.0	61.5	2.0	....	1.1	....	....	....	....	....	....	....	....	....
12/16	0.1	5.1	2.1	27.7	61.6	2.1	....	1.3	....	....	....	....	....	....	....	....	....
12/22	0.1	5.1	2.0	27.9	61.6	2.1	....	1.2	....	....	....	....	....	....	....	....	....
12/28	0.1	5.2	2.0	27.7	61.7	2.2	....	1.1	....	....	....	....	....	....	....	....	....
BUTANE-BUTYLENE																	
2/11	....	....	....	0.6	0.6	24.0	8.7	23.1	42.6	....	0.4	....	....	....	....	....	....
2/18	....	....	....	0.8	0.5	24.5	9.2	23.1	41.5	....	0.4	....	....	....	....	....	....
2/25	....	....	....	0.7	0.7	24.5	9.3	23.6	40.8	....	0.4	....	....	....	....	....	....
3/ 5	....	....	....	0.5	0.4	24.3	8.9	23.1	42.4	....	0.4	....	....	....	....	....	....
					Anhydrous HCl.....			23.6									
					Sulfuric Acid.....			23.4									

of the patterns of the butylenes. It will also be noted that although the composition of the butylenes vary considerably, the accuracy of total butylene content is very good.

Analyses of samples obtained by the mass spectrometer are reproducible. Table 4 compares the analyses obtained from the same samples but at different times. Figure 8 traces the analyses of propane in the depropanizer overhead obtained from alkylation on a daily basis.

The mass spectrometer can accurately determine small amounts of heavy ends in a sample of hydrocarbon gases. In conventional methods of analysis, these heavy ends cannot be detected without difficulty. To illustrate this, the low temperature distillation of the debutanizer overhead from butane recovery from catalytic cracking seldom indicated the presence of pentanes. On this same sample, the mass spectrometer always detects not only pentanes but also pentenes. Until this sample was analyzed by mass spectrometric methods, the pentylene had never been detected.

At Cities Service Refining Corporation, all samples are calculated for all components. Depending on the number of components involved, the results can be reported within 45 minutes from receipt of the sample at the laboratory for the simplest mixtures to two hours for the more complicated mixtures. The instrument time and calculating time for various types of samples is given in Table 5.

Complete calibration runs are made as required. If the calculated pressure and the observed pressure do not check or if scattered drift rather than a consistent drift appears in the pattern of *n*-butane, complete calibrations are made. The length of time between complete calibration runs vary from about one week for a newly installed ionization chamber to a month to six weeks for a well seasoned unit.

Sampling Procedure

The Rubber Reserve directive for sampling the standard Phillips hydrocarbon mixture for mass spectrometric analysis demonstrated that representative samples could not be obtained from the liquid phase and charged directly to the mass spectrometer.

A gas-handling system to obtain representative samples from liquid plant stream samples and to assure no cross contamination between samples has been designed. The container as received is connected to the charging system, Figure 9, and all lines evacuated. About ten ml of liquid sample is vaporized to atmospheric pressure in the 500 cubic inch steel bomb in a water bath maintained at 100° F. After expansion, a small amount of the gas is withdrawn into an evacuated glass receiver of 100 ml capacity. This gas receiver is connected to the gas inlet system and the sample charged to the mass spectrometer.

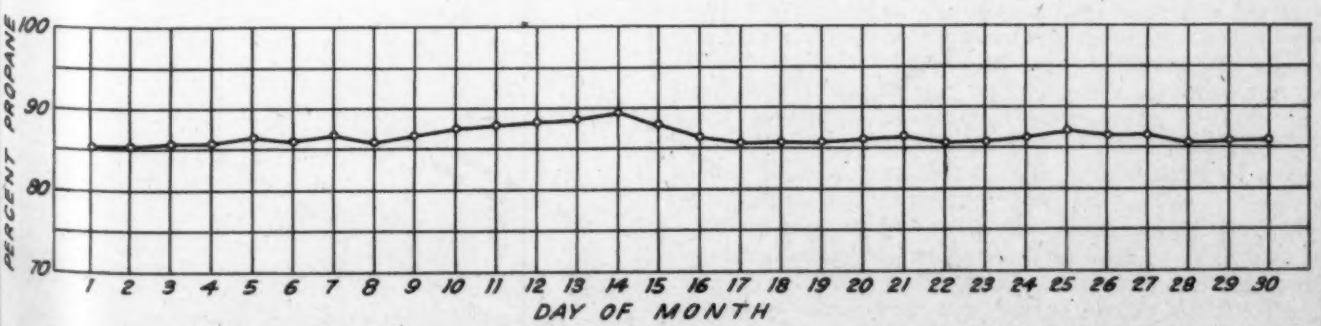


Figure 8. Mass Spectrometer Analysis of Depropanizer Overhead Indicating Change in Propane Content

TABLE 5

Analysis Time Required for Various Plant Streams

STREAM	Number of Components	TIME, MINUTES		
		Instrument	Calculating	Total
Absorber Lean Gas...	12	15	30	45
Absorber Wet Gas....	14	15	35	50
Depropanizer.....	9	15	25	40
Debutanizer.....	9	15	40	55
Isobutane overhead..	6	15	20	35
N-Butane overhead..	5	15	18	33
Unit Gas.....	18	15	60	75

In this way, the disadvantage of withdrawing only a minute portion of the sample from the liquid phase is eliminated.

At the Cities Service Refinery laboratory at Lake Charles, La., the mass spectrometer has superceded low temperature distillation for routine control analysis of light hydrocarbon streams. The efficiency of the gas analysis laboratory has increased from 0.25 to 1.0 analysis per man-hour.

Conclusion

As indicated by the preceding examples, the mass spectrometer in this case is superior to any other method of analysis for routine control analysis of light hydrocarbon streams. In most instances, the mass spectrometer can analyze samples in less time than by any other method with the possible exception of butane-butylene analysis by infra-red spectroscopy.

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ACKNOWLEDGMENT

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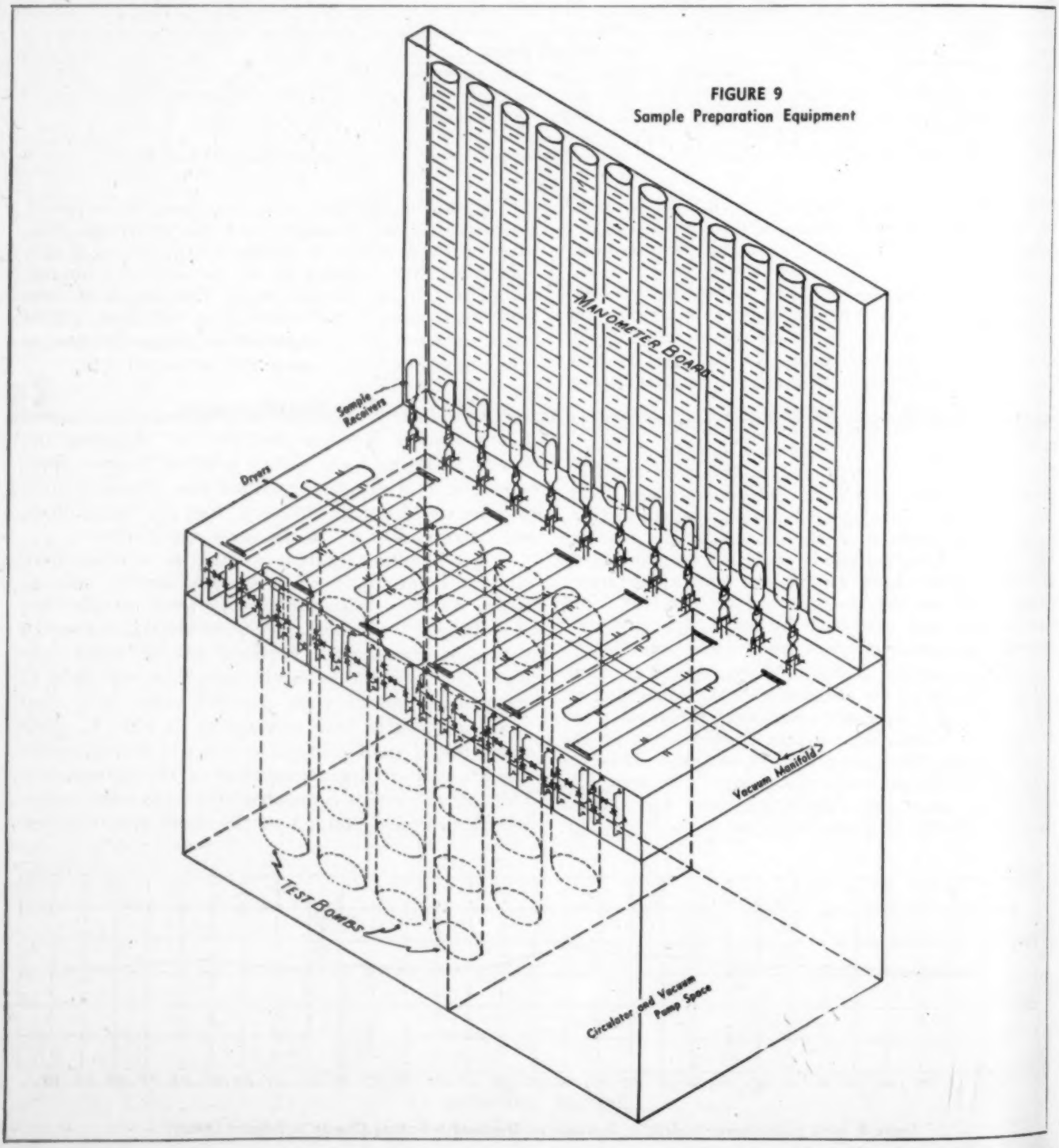

FIGURE 9

Sample Preparation Equipment

Refinery Building Program Is Stupendous

L. J. LOGAN

FACING a substantial increase in the demand for petroleum products over the next few years, the refining branch of the petroleum industry of the United States is confronted with the necessity for a domestic refinery building program beyond any figure heretofore quoted.

According to a study of demand trends and refinery capacities and practices, it is indicated that during the next three years (which is as far as this study attempts to go) it will be necessary to build 250,000 barrels per day of additional crude charging capacity annually, over and above replacements, to recover a minimum prewar margin of unused or reserve capacity, with plants operating by the end of three years at 85 percent of their potential. An average annual net addition of over 375,000 barrels in the daily capacity would be required to get back within three years to an average prewar margin of unused capacity, with crude runs representing 80 percent of potential. Currently, the margin of unused capacity is extremely thin, as plants are pushed to more than 90 percent of capacity and substantial amounts of marginal, inefficient capacity is employed. (In prewar years the best year's average operating percentage was 85 percent in 1941. Average for nine years, prewar, was 80 percent of capacity.)

The presently needed increases in capacity as indicated above would be substantially more than those contemplated in plans so far announced for refinery construction. Such announced plans indicate an annual construction rate of approximately 200,000 barrels daily of new capacity, part of which will merely replace existing old equipment. It should be added, however, that the total of announced construction could be materially increased overnight, bringing the industry's actual plans closer in line with the indicated needs, as plans for refinery expansion usually are not made public until contracts are awarded.

U. S. Refinery Capacity, Runs to Stills, and Operating Rates, by Years, 1935 to Now and Projections to 1951

Capacities from American Petroleum Institute; Runs from U. S. Bureau of Mines.

YEAR	Refining Capacity Jan. 1 (Bbls. Daily)	Daily Average Crude Runs to Stills During Year	
		Barrels Daily	As Percent of Jan. 1 Capacity
1935	3,795,000	2,646,000	69.7
1936	3,869,000	2,920,000	75.5
1937	3,954,000	3,242,000	82.0
1938	4,159,000	3,192,000	76.7
1939	4,211,000	3,391,000	80.5
1940	4,441,000	3,536,000	79.6
1941	4,535,000	3,861,000	85.1
1942	4,647,000	3,655,000	78.7
1943	4,806,000	3,917,000	81.5
1944	4,827,000	4,551,000	94.3
1945	4,908,000	4,711,000	96.0
1946	5,408,000	4,740,000	87.6
1947	5,556,000	5,021,000	90.4
1948	*5,771,000	*5,225,000	90.5
Minimum Capacity Needed to Hold Operating Rate Down to 90 Percent:			
1949	5,928,000	*5,335,000	90.0
1950	6,044,000	*5,440,000	90.0
1951	6,167,000	*5,550,000	90.0
Operating Rates Required on Basis of Increasing Capacity 200,000 Barrels Daily Per Year:			
1949	5,971,000	*5,335,000	89.3
1950	6,171,000	*5,440,000	88.2
1951	6,371,000	*5,550,000	87.1
Refinery Capacity Needed on Most Active Prewar Basis of Operating 85 Percent of Capacity:			
1946	5,576,000	4,740,000	85.0
1947	5,907,000	5,021,000	85.0
1948	6,147,000	*5,225,000	85.0
1949	6,276,000	*5,335,000	85.0
1950	6,400,000	*5,440,000	85.0
1951	6,529,000	*5,550,000	85.0
Refinery Capacity Needed on Average Prewar Basis of Operating at 80 Percent of Capacity:			
1946	5,925,000	4,740,000	80.0
1947	6,276,000	5,021,000	80.0
1948	6,531,000	*5,225,000	80.0
1949	6,669,000	*5,335,000	80.0
1950	6,800,000	*5,440,000	80.0
1951	6,937,000	*5,550,000	80.0

* Estimated by Petroleum Refiner.

Pushing to Top Limits

The industry currently is pushing available refinery capacity to top limits, operating above rated capacity in many cases, and employing some units that are obsolete, in poor condition, or otherwise uneconomic to operate. During the coming winter it will be "touch and go" for the refineries to supply all of the products required. There is no margin of unused capacity which can be put into operation when unforeseen difficulties arise, such as severe weather, work stoppages, or catastrophes.

When the United States entered the war the country was fortunate in having refinery capacity considerably in excess of its current requirements and which was brought into essential use during the war.

The happy prewar condition does not exist today, as the margin of unused capacity has not been restored. Instead, the industry is faced with the necessity of trying to catch up with the normal capacity that would have been built up during the war years and to provide for the future expansion of the demand for petroleum products.

In recognition of the acute need for refinery expansion, numerous companies are now pushing construction and modernization projects. PETROLEUM REFINER has tabulated information on projects which have been announced, and although the compilation probably omits considerable work, it includes about 50 important projects, of virtually all categories, under construction or definitely planned and expected to be completed mostly in 1947 and 1948.

The American Petroleum Institute recently made a survey which indicated that the industry would spend more than $1.1 billion in 1947 and 1948 for new and improved refining division facilities to provide 407,000 barrels per day of new capacity, of which 100,000 will represent replacements of obsolete or worn out refineries, while the remaining 307,000 barrels a day will represent new and additional refining capacity. It was stated that announcement of other new plants was expected shortly.

Fairly well in line with the API survey but looking ahead only through the first half of 1948 was a recent report on U. S. refining capacity by the committee on refining capacity of the National Petroleum Council, headed by Dr. Robert E. Wilson, chairman

Petroleum Refining Capacity of the United States, June 30, 1947

Source: Committee on Petroleum Refining Capacity of the National Petroleum Council.

(Daily Crude Oil Throughput in Barrels of 42 Gallons)

P.A.W. District	Capacity of Operating Refineries	Capacity of Shutdown Refineries	Total Capacity
District 1 (Eastern)	936,275	5,500	941,775
District 2 (Mid-West)	1,406,880	49,560	1,456,440
District 3 (Southwest)	1,928,825	133,000	2,061,825
District 4 (Rocky Mt.)	177,617	3,595	181,212
Total E. of California	4,449,597	191,655	4,641,252
District 5 (W. Coast)	970,950	35,900	1,006,850
Total U. S.	5,420,547	*227,555	5,648,102

* Including about 85,000 barrels per day of capacity shut down due to strikes and balance of 142,555 daily shut down for other reasons.

of the board, Standard Oil Company (Indiana): On the basis of information furnished by companies known to plan new construction, the committee estimated that additional refining capacity would be installed in the amount of 213,300 barrels per day in the last three quarters of 1947 and in the amount of 54,200 barrels in the first half of 1948, a total of 267,500 barrels daily in the 5 quarters ending at mid-1948. Dates for completion of the new daily average crude charging capacity are scheduled as follows:

PERIOD	Bbls. Day
Second Quarter, 1947	54,700
Third Quarter	139,100*
Fourth Quarter	19,500
First Quarter, 1948	40,200
Second Quarter	14,000

* 40,000 for replacement; 99,100 to be net addition to capacity.

This current construction is on the basis of more than 200,000 barrels per year of new capacity and of nearly that much net addition to existing capacity over and above the construction devoted to replacement of old units.

Although impressive, being somewhat above prewar normal, this scale of refinery construction work represents a minimum of essential expansion for keeping abreast of growing oil consumption, affording little or no possibility of building up reserve or emergency capacity.

In order to show how much refining capacity would have to be increased to permit nearer normal operating rates and their efficiencies and advantages, a table is here presented, embodying projections of necessary crude runs to stills over the next several years and also indicating normal operating rates before the war, when refinery runs normally averaged somewhat less than 80 percent of capacity and never exceeded 85 percent on an annual basis even in highly active years. The table shows how much refinery capacity would be required to meet projected necessary runs by operating plants at several different percentages of capacity.

As a starting point, it is found that for the year 1947, refinery runs are estimated at 5,021,000 barrels daily, equivalent to 90.4 percent of the capacity of 5,556,000 barrels per day available on January 1, 1947, API basis. This is the highest annual rate for peace time in modern history. In contrast, the corresponding operating rates for the 7 years before Pearl Harbor and the 2 years thereafter averaged only 78.8 percent of capacity, having been around or under 75 percent for several individual years and only 85.1 percent (in 1941) at the highest.

To provide estimated refinery runs of 5,225,000 barrels daily in 1948, the industry would have to operate at 90.5 percent of the scheduled January 1, 1948, capacity of 5,771,000 barrels daily. To provide the same runs on an operating rate of 85 percent of capacity as of January 1, 1948, would require the existence at that time of a capacity of 6,147,000 barrels daily instead of the 5,771,000 expected to be available. On this basis there will be at the beginning of 1948 a deficiency of 376,000 barrels per day of capacity. If the industry were to eliminate this indicated current deficiency in refinery capacity gradually in 1948, 1949, and 1950, getting down to an 85 percent operating rate by the end of that time and meanwhile also taking care of normal growth in demands for oils, it would have to build up the capacity from the 5,771,000 barrels daily as of January 1, 1948, to an estimated 6,529,000 daily on January 1, 1951. This would be a total net increase of 758,000 barrels in U. S. capacity in the three years, or an average net addition of slightly over 250,000 barrels per day annually, not counting new capacity used in replacement of old facilities.

If the industry were to limit its refinery expansion to the net addition of 200,000 barrels per day of new capacity annually, in line with presently disclosed plans, then it would still have to be operating three years from now at the comparatively high rate of 87 percent of capacity.

Big Increase Seems Required

To provide the 5,225,000 barrels per day of refinery runs estimated for 1948 by operating at the prewar average rate of 80 percent of January 1, 1948, capacity would require the existence at that time of 6,531,000 barrels per day of capacity instead of the 5,771,000 barrels expected to be available. Figured on the 80 percent operating rate, there will be at the beginning of 1948, therefore, a deficiency of 760,000 barrels per day of capacity. If the industry were to eliminate this deficiency gradually in 1948, 1949, and 1950, expanding facilities enough to take care of growth in demand and enough also to permit reduction of operations to 80 percent of capacity by 1951, then the capacity itself would have to be built up from the expected 5,771,000 barrels as of January 1, 1948, to 6,937,000 barrels daily as of January 1, 1951. This would be a total net increase of 1,166,000 barrels in U. S. daily capacity in the three years, or an average net addition of 388,000 barrels per day annually.

New Refinery Capacity Expected to Begin Operating in 1947 and First Half of 1948

As reported to Committee on Refining Capacity of the National Petroleum Council by companies owning 90 percent of the March 31, 1947, capacity of U. S. plants.

(Daily Crude Oil Throughput in Barrels of 42 Gallons)

	1947			1948	
P.A.W. District	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter
District 1 (Eastern)	1,500	.....	.....	.....	.....
District 2 (Mid-West)	31,700	22,600	19,500	16,700	.....
District 3 (Southwest)	13,500	19,500	.....	23,500	14,000
District 4 (Rocky Mt.)	2,000	7,000	.....	.....	.....
Total E. of California	48,700	49,100	19,500	40,200	14,000
District 5 (W. Coast)	6,000	*90,000	.....	.....	.....
Total U. S.	54,700	*139,100	19,500	40,200	14,000

* 85,000 of this originally intended for replacement because of existing conditions. But it is now planned to use only 40,000 as replacement. The remaining 45,000 which was to have been replaced is continued in operation for an indefinite period because of the increased demand for crude running capacity.

The Suspensoid Catalytic Cracking Process

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THE Suspensoid cracking process has been employed by Imperial Oil Limited over the past six or seven years in full scale commercial units and their experience has established low cost operation well suited to present day requirements for high octane gasolines. The process is considered of especial importance for small refineries because of simplicity and flexibility and because the usual thermal cracking unit can be converted to Suspensoid operation without extensive alteration or additions.

THE fundamental features which distinguish the Suspensoid catalytic cracking process from all other commercial processes for the catalytic conversion of hydrocarbons are the utilization of very small quantities of catalyst and the absence of special reactors. Powdered catalyst, in the form of an oil slurry, is charged with the feed to a conventional type of thermal cracking coil and the catalyst is recovered from the product tar by filtration, after which it may be regenerated and re-used. Between 2 and 10 pounds of catalyst per barrel of total feed are customarily employed. The simplified flow diagram given in Figure 1 illustrates the readiness with which a thermal cracking unit may be converted to suspensoid catalytic cracking operations. Descriptions of the accessory equipment may be found in the literature.[1,2]

A wide variety of feed stocks, ranging from naphtha to heavy gas oils and cycle stocks, may be processed in a single refinery unit. The flexibility of the suspensoid cracking operation together with its simplicity is particularly valuable in small refineries. Any type of feed stock may be processed provided complete vaporization in the coil is attained. In order to assist in vaporizing heavy stocks it may be desirable to add a carrying agent such as naphtha, water, propane, or butane fractions to the feed. It has been found, however, that when cracking at severe conditions to a given pool octane number, appreciably higher distillate yields are obtained if the naphtha and gas oils are charged as a mixed feed to a suspensoid cracking unit rather than separately reforming the naphtha and suspensoid cracking the gas oils.[3]

TABLE 1

Comparison of Thermal and Suspensoid Cracking Results

	Thermal Cracking and Reforming	SUSPENSOID CRACKING*	
		Normal Operations	Severe Operations
Yields Excluding Polymer Gasoline:			
Gasoline, 10 lbs. RVP, 400 °F. end pt., L.V percent	56.1	52.3	53.0
Heating oil, L.V. percent	12.7	12.7	5.1
Fuel oi, 10° API gravity, L.V. percent	25.6	20.2	19.0
Excess butane, L.V. percent	1.3	4.5	6.0
Dry gas (propane and lighter), Wt. percent	6.7	12.5	20.4
Coke, wt. percent	0.3	0.2	0.2
Gasoline ASTM motor octane number, unleaded	65.4	73.2	75.0
CFR research octane number, unleaded	71.0	82.0	85.0
CFR research octane number, + 3cc. TEL	84.8	91.4	94.0
Yields Including Polymer Gasoline:			
Gasoline, 10 lbs RVP 400 °F. end pt., L.V. percent	58.3	58.6	62.8
Heating oil, L.V. percent	12.7	12.7	5.1
Fuel oil, 10° API gravity, L.V. percent	25.6	20.2	19.0
Excess butane†, L.V. percent	Nil	Nil	Nil
Dry gas (propane and lighter), wt. percent	5.9	10.5	16.8
Coke, wt. percent	0.3	0.2	0.2
Gasoline ASTM Motor octane number, unleaded	66.6	75.5	78.1
CFR research octane number, unleaded	72.6	85.1	89.0
CFR research octane number + 3 cc. TEL	85.6	93.2	96.2

* Catalyst—Natural and activated clays from lube contacting two pounds per barrel of feed.
† Excess over requirements to make 10lb RVP gasoline.

Refinery Operations

Plant scale suspensoid cracking has been conducted at the Sarnia Refinery of the Imperial Oil Limited as a normal operation since 1940, following several years of experimental developments by the company. Natural and activated clays which had been used to contact treat lubricating oils provided low cost catalysts which were sufficiently active to meet current requirements. Typical operating conditions were coil outlet temperatures of 1045 to 1055°F. and coil outlet pressures of 350 to 450 psig. It was found possible to increase the fresh feed rate to the coils over and above that used in the previous thermal cracking operations and still gain an advantage in the octane number of the distillate produced, of approximately 8 points by the ASTM Motor method, and 11 points by the Coordinating Fuel Research method. Appreciable yields of propylenes and butylenes were also produced. This feature of the process was utilized when the rubber emergency arose during the war, and the Dominion government built a synthetic rubber plant at Sarnia. To supply the maximum quantity of butylenes for this plant the severity of cracking in the suspensoid operations was further increased, with coil outlet temperatures ranging from 1080 to 1090°F. and somewhat reduced feed rates. Simultaneously, of course, increased octane numbers were realized on the gasoline produced.

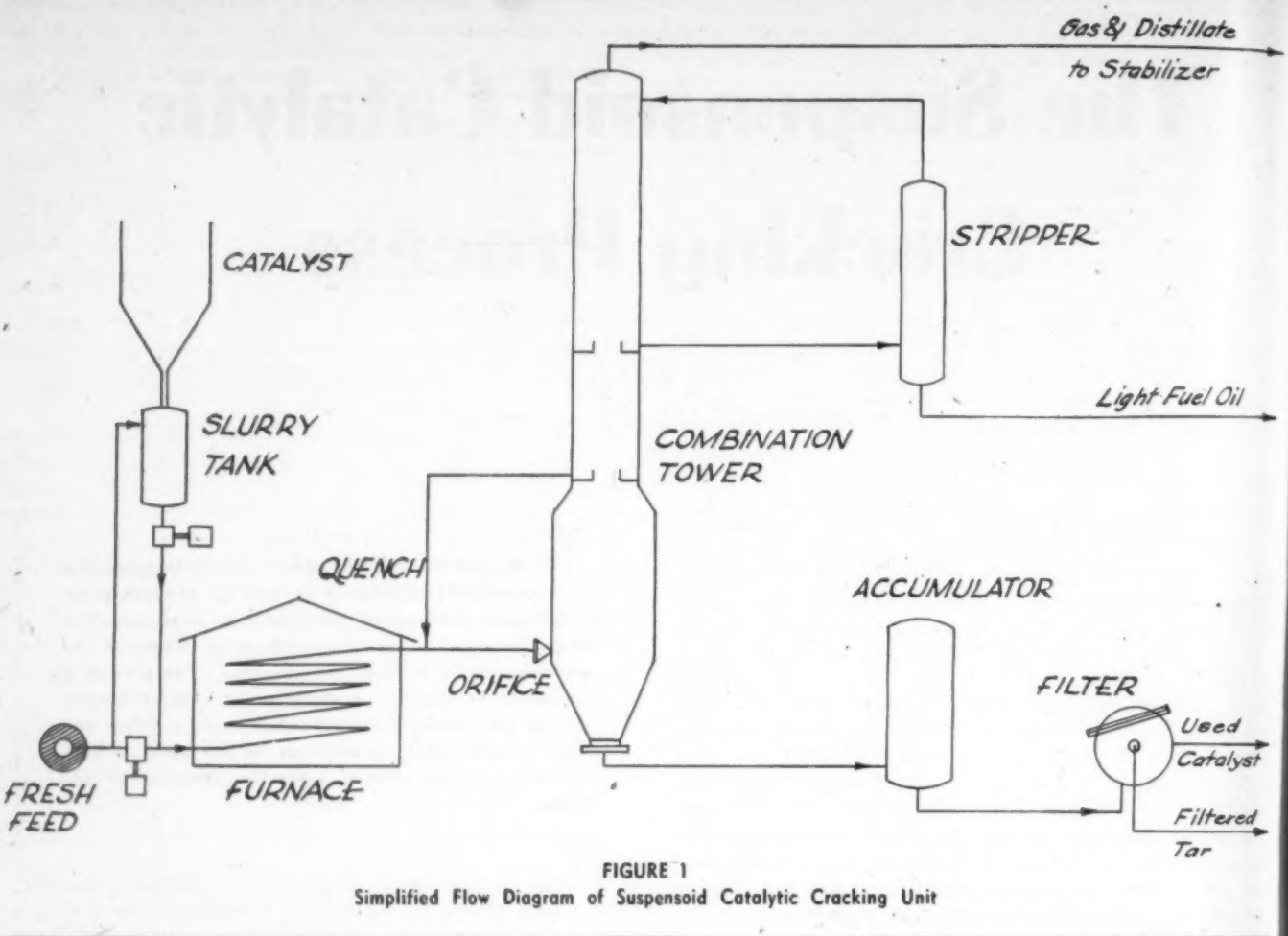

FIGURE 1
Simplified Flow Diagram of Suspensoid Catalytic Cracking Unit

Typical yields from these operations are given in Table 1. It will be noted that when polymer gasoline was included in both processes, the suspensoid operations gave increased yields of gasoline with octane numbers ranging from 9 to 12 points by the Motor method, and 12 to 16 points by the CFR Research method, above those obtained by thermal cracking similar feed stocks in the same equipment.*

These years of commercial operation demonstrated that the process was thoroughly sound and practical for routine commercial operations. The various mechanical difficulties which arose in the development of the process were eliminated or reduced to such negligible proportions that service factors equal to those attained in thermal cracking operations were realized.

Pilot Plant Tests with Synthetic Catalysts

While the product quality obtained in the above refinery operations using natural clays, once through, is adequate for present day requirements, it was realized that future developments would result in a demand for gasoline with octane numbers which could only be obtained by the use of highly active cracking catalyst. Such catalysts, of course, would be regenerated and recycled to the process.

Experiments in this field were most readily conducted in a pilot plant which was especially built for the purpose, and which closely reproduced the conditions and results obtained in the full scale units.

Runs in the pilot plant demonstrated that the utilization of fresh 3A catalyst, which is a typical synthetic cracking catalyst commercially available at the present time, would produce gasolines having clear octane numbers approximately two points higher than those obtained when cracking to the same conversion** with the natural and activated clays from lube oil contacting. Product distributions at a given conversion were essentially the same using either catalyst. When including nonselective polymer gasoline (produced from the propylene and excess butylenes) gasoline yields of 61 percent were obtained from Mid-Continent-Louden feed stocks composed of 25 percent of heavy naphtha and 75 percent of mixed gas oils. The ASTM Motor method octane number of this gasoline reached 80, and the CFR octane number 91, without the addition of tetraethyl lead.

Regenerated 3A catalyst*** gave results approaching those of the fresh material, but gave slightly higher yields of gasoline with somewhat lower octane numbers.

Alternative cracking catalysts which have been investigated to date also tended to produce slightly higher yields of gasoline which had lower octane numbers than those resulting from the use of 3A. However, the field of preparing catalysts for petroleum cracking is in an active state of develop-

* By increasing the severity of the naphtha reforming operation, the octane numbers of the pool gasoline produced in the thermal case could have been raised three or four points with a corresponding loss in yield.

** The yield of C_3 and lighter products has been found to give satisfactory indication of cracking severity in the suspensoid process.

*** Obtained from commercial "fluid cracking" units.

TABLE 2

Suspensoid Cracking Mid-Continent-Louden Feed Stocks

Catalyst.....Fresh 3A 10 lbs./Bbl.
Coil Pressure.....600 psig.
Feed Rate.....0—10 V/V/Hr.*

Feed API gravity..... 40.7
Naphtha content..... 40 L.V. %
Engler distillation 50 percent off at..... 518° F.

Approximate coil outlet temperature†, °F	1060	1105
Yields Excluding Polymer Gasoline:		
Gasoline 10 lbs. RVP, 400° F. B.P.—Volume percent	56.5	53
Heating Oil (415–600° boiling range)—Volume percent	16 (28° API gravity)	8 (20° API gravity)
Fuel Oil (Over 600° boiling range)—Volume percent	8.5 (7° API gravity)	9 (0.5° API gravity)
Excess butane‡—Volume percent	5	8
Dry gas (propane and lighter)—Weight percent	16	24
Coke—Weight percent	0.8	1.0
Gasoline Octane Numbers:		
ASTM Motor method unleaded	75.0	78.3
ASTM Motor method +3 cc. TEL	82.9	84.2
CFR Research method unleaded	86.3	90.0
CFR Research method +3 cc. TEL	93.7	96.4
Gasoline Including Polymer—10 Lbs. RVP:		
Yield on fresh feed—Volume percent	62.5	62.5
ASTM Motor octane number unleaded	76.0	81.0
CFR Research octane number unleaded	87.0	91.0

* Volumes of liquid feed (at 60° F.) per volume of coil above 800° F. per hour.
† Temperature of lead bath at the outlet section of the coil.
‡ Excess over requirements to make a 10 lb. RVP gasoline.

ment. The results already attained show that the Suspensoid process in sensitive to, and will profit by further improvements in catalyst activity.

As the octane number requirements for motor gasoline increase, the problem of upgrading the light naphtha produced from most crudes become increasingly acute. In the case of suspensoid catalytic cracking, one solution is to include such light naphtha in the total feed to the operation. The results of cracking such a mix are given in Table 2 in which results at two different conversions are reported. In these operations the feed stock was composed of 15 percent of light naphtha, 25 percent of heavy naphtha and 60 percent of mixed gas oils, all from Mid-Continent-Louden stocks. Since this feed represented the total stock available for motor gasoline production, the resulting distillate represented a refinery pool gasoline. As such, unleaded Motor octane numbers around 80 and Research octane numbers of 90 (including polymer gasoline) were notably high.

Effect of Feed Source

The greater part of the research conducted to date has been concerned with the suspensoid cracking of feed stocks derived from Mid-Continent-Louden crudes. A few runs have been carried out using feed stocks derived from other crudes. These indicate that, as would be expected, the nature of the crude has an appreciable effect on the yields and quality of the cracked products.

Table 3 illustrates the results of suspensoid cracking feed stocks from four different crudes, in order of decreasing paraffinicity, at a constant conversion to dry gas. Although the feed stocks varied widely in distillation characteristics, the octane numbers of the unleaded gasolines produced increased in order of decreasing paraffinicity as measured by the characterization factor. Leaded octane numbers showed a similar increase with the exception of the product from Lloydminster feed, which was higher in sulphur content than the other gasolines. Although the naphtha content of the feed obviously plays a large part in determining the yield of gasoline at a given conversion, other characteristics of the feed also have an important effect on all the product yields. Sufficient data is not yet available to allow general correlations to be made, so that the results of suspensoid cracking an unfamiliar feed can only be estimated in a very qualitative manner.

TABLE 3

Suspensoid Cracking Feed Stocks from Various Crudes

(Feed Rate 9 V/V/Hr. Coil Pressure 600 psig.)
Catalyst—Fresh 3A, 10 Lbs./Bbl.

CRUDE SOURCE	Mid-Continent-Louden	Jusepin	Colombian	Lloydminster
Feed Inspections:				
Gravity, °API	40.7	43.3	38.4	34.5
Naphtha content (400° Engler FBP) L.V. percent	40	49	35	27
Engler 50 percent, pt., °F	509	439	464	484
Characterization Factor	11.9	11.8	11.6	11.5
Conversion to Dry Gas—wt. percent on feed	15	15	15	15
Yields—Excluding Polymer Gasoline:				
Gasoline, 10 lbs. RVP, 400 °F. B.P. L.V. percent	56.5	63.0	57.4	56.1
Heating oil (415-600 °F. boiling range), L.V. percent	19.0	13.6	20.2	18.2
Fuel oil (over 600 °F. boiling range), L.V. percent	8.5	5.0	5.3	6.6
Excess butane,* L.V. percent	5.0	5.6	4.7	7.5
Coke, weight percent	0.8	1.0	0.8	1.1
Gasoline Octane Numbers:				
ASTM Motor method, unleaded	74.6	77.4	80.0	80.0
ASTM Motor method, + 3 cc. TEL	83.0	84.2	85.7	84.0
CFR research method, unleaded	86.0	88.0	91.6	92.5
CFR research method, +3 cc. TEL	93.2	95.0	96.8	96.2
Gasoline Including Polymer—10lb RVP:				
Yield—LV percent on feed	62.5	68.9	63.1	62.8
ASTM motor octane number, unleaded	76.0	78.3	80.5	80.5
CFR research octane number, unleaded	87.0	90.6	91.8	92.7

* Excess over requirements to make a 10lb RVP gasoline.

The experience of the Imperial Oil Limited in operating full scale suspensoid catalytic cracking units over the last six or seven years had established the fact that this is a low cost operation, well suited to present day requirements. The simplicity and flexibility of the process make it particularly attractive to the operators of smaller refineries. It has been the purpose of this paper to demonstrate that its potentialities are such as to enable it to meet any requirements which further developments in the automotive industry may make. The octane numbers of the gasolines produced from mixtures of all available feed stocks, and therefore representing refinery pool gasolines, invite comparison with other processes at present available to the industry.

REFERENCES

1 "Suspensoid Catalytic Cracking System gives nearly 60 percent Gasoline Yield," Arch L. Foster, Oil and Gas Journal, May 4, 1944.
2 "Suspensoid," Oil and Gas Journal, March 30, 1946.
3 "New Developments in Suspensoid Catalytic Cracking," C. F. Burk. Oil and Gas Journal, October 12, 1946.

Closed Vent System Increases Plant Operating Safety Factor

Inlet gas separators at the Carthage, Texas, plant of United Gas Pipe Line Company, showing location of safety valves 1A and 1B, and connections to 16-inch flare line in foreground. Safety valves 43 A, B, C, and D, in the right background, are connected to the flare line by a 6-inch line.

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United Gas Pipe Line Company
Carthage, Texas

AMONG the improvements in the operation of gasoline and cycling plants is a noticeable trend toward increasing the safety factor in the handling of vent and safety valve blowoff gas. Processing gas at high pressures in vessels and equipment capable of containing these pressures has resulted in an increase in the investment cost of the plant. The size of the more recently constructed plants to process large volumes of gas has required more operating personnel. Obviously, the outstanding advantage of increasing the operating safety factor is to provide better protection for personnel and plant.

Conventional practice has been to install safety valves on top of towers and tanks and permit them to blow to the atmosphere. This method has been satisfactory in view of the fact that relatively small volumes of gas were blown to the atmosphere from the process equipment through the safety valves, usually because the plant was not operating at high pressures and had a more simplified flash system. In addition, provision was made for the connections to a flare line for use in starting up and shutting down the plant, so that large volumes of vented gas were safely flared outside the plant area.

In the safety valve discharge system described herein, which was installed during construction of the Carthage, Texas, gasoline plant of United Gas Pipe Line Company, it will be noted that the conventional flare line has been extended to handle the gas from the safety valves and so eliminates venting of any combustible gas in the processing area. Careful design of the system is reflected in line and safety valve sizing, equipment connections, and in the final disposal equipment for the vented gas. The system has operated satisfactorily since the plant began operation. When a valve begins to blow, its location is quickly found by the operators by the sound. Each valve pops with a different sound which depends on the pressure in the vessel and valve and line size.

Flow Lines and Valves

In the diagram of Figure 1 is shown the line sizes and vessel connections to the vent line. The vent line is overhead in the process area and is clamped onto concrete piers about 18 inches above ground from the process area to the flare stack. This method permits frequent inspection, eliminates possibility of underground corrosion, and permits new equipment to be connected without excavation in the plant area. An economical feature of the system is the location of the safety valves on the lower portion of the vapor lines to the various towers, which eliminates extra piping that would be required for the valves on top of the towers. Also, this location of the safety valves make them more accessible for inspection and adjustment.

The arrangement of piping involves the use of branch lines from the main line of the vent system, as shown on the flow diagram. This method substantially reduced the amount of large diameter pipe required, because the branch headers are relatively short in length and smaller in diameter than the large main line which is designed to handle large volumes of gases released by several valves in simultaneous operation. The capacity of the lines is

increased several times between individual safety valves and the main 16-inch line to the flare stack. This reduces the pressure losses from flowing friction in the header, and insures that only minor variations in the relieving points of the various safety valves will be occasioned by altered differential pressures across the valves.

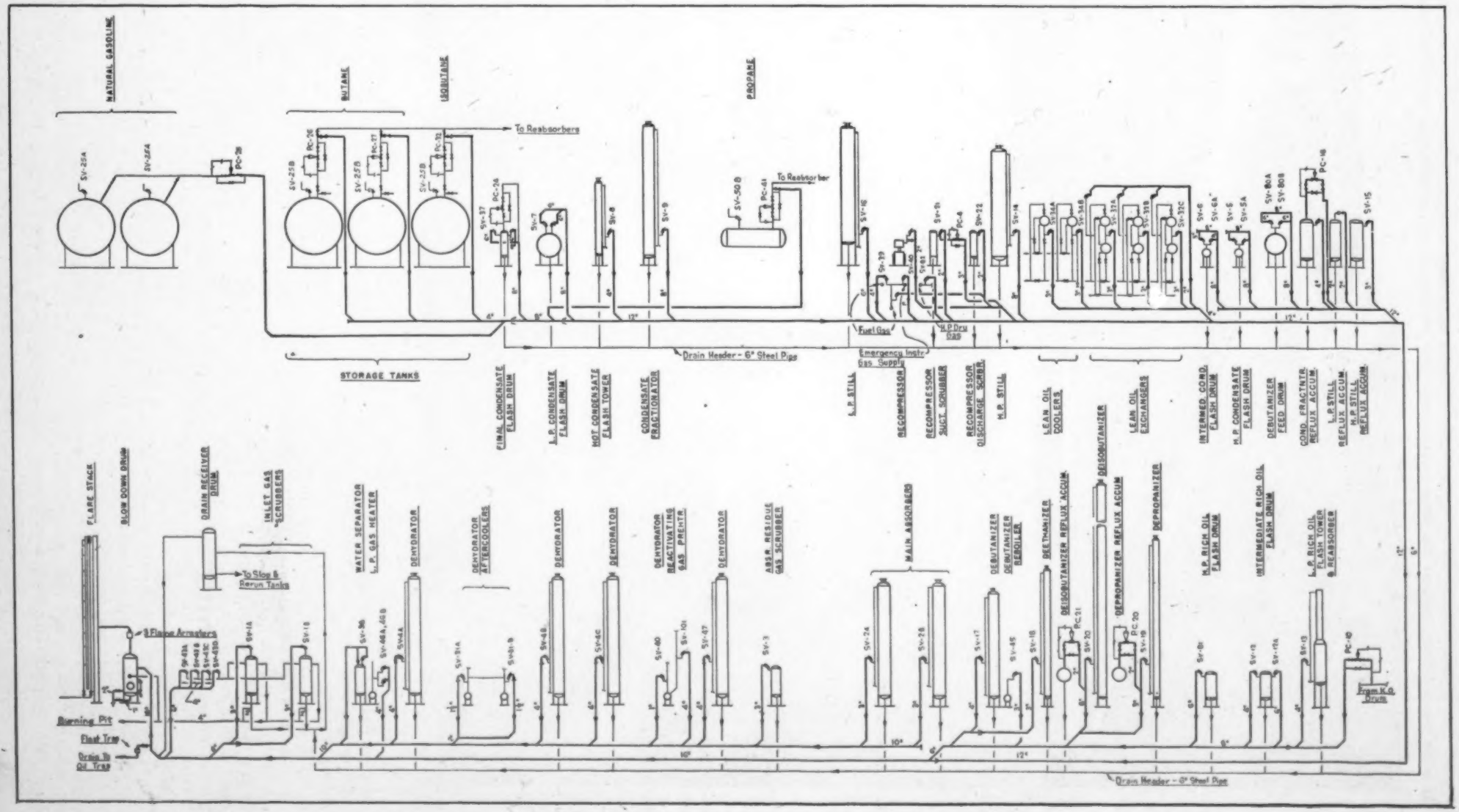
For example, there are two nozzle type safety valves of different sizes, 3-inch and 1½-inch on the high pressure condensate flash drum, each having a different pressure setting. The 3-inch valve is set at 536 psig. and from its 4-inch outlet, vented gas flows through a 6-inch line to an 8-inch header and then to the 12-inch branch line, which connects to the 12-inch diameter main flow line. The smaller valve, set at 550 psig. has a 2-inch outlet and also connects to the 8-inch header through a 6-inch line. Dual valves provide at least the total venting capacity needed on the drum and reduce the possibility of the valves not opening at the set pressures.

Pressure Control Valves

As will be noted from the flow sheet, vent lines from the storage tanks for natural gasoline, butane, isobutane, and propane are equipped with back pressure control valves to obtain a more sensitive control. Also, the vapors from these tanks can be returned to the low pressure flash tower and reabsorber instead of wasting to the flare system except when desired. All tanks are equipped with the conventional type safety valves vented to atmosphere for additional fire protection, but are set at a higher releasing pressure to prevent their operation except during emergency. Vent vapors flow through 4-inch lines into the 4-inch vent header which is the smallest header line in the system. The header diameter is

Sixteen-inch safety valve vent gas line and flare stack of United's Carthage plant. The blowdown drum and overhead flame arrestors are at the base of the stack.

Flow Diagram Showing Location of Safety Valves, Blowdown Lines and Drain Headers



ITEM	SIZE		SETTING	
	INLET-LBS	OUTLET-LB	P.S.I.	TEMP°F
SV-1A & B	2" 1500 RF	3"150 RF	1200	100
SV-2A & 2B	"	"	"	"
SV- 3	"	"	"	"
SV-4A,B,C,D	"	"	"	"
SV-5	1½" 300 RF	2" 150 RF	550	"
SV-6	3" Scr.	3" Scr.	250	"
SV-7	4" 250 RF	6" 125 FF	110	"
SV-8	3"-250 RF	4"-125 FF	75	150
SV-9	6" 250 RF	8" 125 FF	50	300
SV-10	3" 250 RF	4" 125 FF	55	200
SV 12	3" 400 RF	4" Scr	250	100
SV-13	3" 250 RF	4" 125 FF	75	150
SV-14	6" 250 RF	8" 125 FF	105	205
SV-15	3" Scr.	3" Scr.	125	100
SV-16	4" 250 RF	6" 125 FF	50	320
SV-17	4"-400 RF	4" Scr	300	140
SV-18	2" 300 RF	3" 150 RF	500	120
SV-19	3" Scr	3" Scr	265	120
SV-20	4" 250 RF	6" 125 FF	140	190

ITEM	SIZE		SETTING	
	INLET-LBS	OUTLET-LB	P.S.I.	TEMP°F
SV-21	1½" 300 RF	2" 150 RF	250	100
SV-22	"	"	520	200
SV- 23A, 23B*	4" 250 RF	6" 125 FF	150	140
SV-24*	"	"	"	165
SV-25A, 25B*	"	"	50	150
SV- 26	1" Scr.	1½" Scr.	520	200
SV-27*	3" 250 RF	4" 125 FF	125	353
SV-28*	4" 250 RF	6" 125 FF	40	287
SV-29 A, 29B*	1" Scr	1½" Scr	400	100
SV-30	¾" Scr	1" Scr.	1200	100
SV-31A, 31B	¾" Scr	1" Scr	"	"
SV-32A,B,C	3" Scr	3" Scr.	150	405
SV-33A,B,C	2" Scr	2" Scr.	200	340
SV-34A, B	2"-400RF	3" Scr	150	140
SV-35A, B*	2" Scr.	2½" Scr.	150	100
SV-36*	2" 250 RF	3" 125 FF	100	200
SV-37	4" 250 RF	6" 125 FF	20	60
SV-38				
SV-39	3" 250 RF	4" 125 FF	50	100
SV-40	¾" Scr	1" Scr.	60	100

ITEM	SIZE		SETTING	
	INLET LBS	OUTLET LB	P.S.I.	TEMP°F
SV-41 Δ	2" 250 RF	3" 125 FF	150	366
SV-42 A, B*	3" 1500 RF	4" 150 RF	2@ 1130 1@ 1133	100
SV-43A,B,C,D	3" 1500 RF	4" 150 RF	2@ 1040 1@ 1050	100
SV-44A,B,C*	3" 1500 RF	4" 150 RF	1@ 1040 1@ 1050	100
SV-45	2" 250 RF	3" 125 FF	275	230
SV-46A, B	3" 250 RF	4" 125 FF	75	100
SV-47	3" 250 RF	4" 125 FF	275	100
SV-48	2" 250 RF	3"-125 FF	250	100
SV-49*	¾ Scr	1" Scr.	125	100
SV-50 A, B*	3" 250 RF	4" 125 FF	216	120
SV-51*	¾" Scr	1" Scr	50	450
SV-52*	"	"	"	"
SV-53 Δ	½" Scr	½" Scr.	125	90
SV-54 Δ	"	"	"	"
SV-55 Δ	"	"	"	"
SV-56 Δ	"	"	230	100
SV-57 Δ	"	"	125	90
SV-58 Δ	"	"	"	"
SV-59 Δ	"	"	"	"
SV-60 Δ	"	"	"	100

ITEM	SIZE		SETTING	
	INLET LBS	OUTLET LBS	P.S.I.	TEMP°F
SV-61 Δ	½" Scr.	½" Scr.	125	100
SV-62 Δ	"	"	250	"
SV-63 Δ	"	"	"	"
SV-64 Δ	"	"	"	"
SV-65 Δ	"	"	"	90
SV-66 Δ	"	"	125	"
SV-67 Δ	"	"	"	"
SV-68 Δ	"	"	"	"
SV-69 Δ	"	"	"	"
SV-70 Δ	"	"	"	"
SV-71 Δ	"	"	"	"
SV-72 Δ	"	"	"	120
SV-73 Δ	"	"	"	"
SV-74 Δ	"	"	"	100
SV-75 Δ	"	"	"	120
SV-76 Δ	"	"	"	90
SV-77 Δ	"	"		90
SV-78*	¾" Scr.	1" Scr.		450
SV-79*	2" 250 RF	3" 125 FF	85	90
SV-80 A, B	4" 250 RF	6" 125 RF	105	120

ITEM	SIZE		SETTING	
	INLET LBS	OUTLET LBS	P.S.I.	TEMP°F
SV-81	2" 300 RF	3"150 RF	550	100
SV-82				
SV-83 Δ				
SV-84*				
SV-85 Δ	¾" Scr.	½" Scr.	125	90
SV-86 Δ	½" Scr.	½" Scr.		
SV-87 Δ	"	"		
SV-5A	3" 300 RF	4"150 RF	536	100
SV-6A	3" 250 RF	4" 125 FF	250	100
SV-12A	2" 250 RF	3" 125 FF	290	100

NOTE:
Safety Valves Marked With* Will Blow To Atmosphere
" " " Δ " " Oil Separator

increased to 8-inches and the final condensate flash drum connected to this section through two safety valves set at 20 psig. having 4-inch inlets and 6-inch outlets and an 8-inch line. A pressure control valve is used on this vessel, also, to maintain pressure constant at 20 psig. Also tied into the 8-inch header is the propane storage tank, which as mentioned previously, employs a pressure control valve.

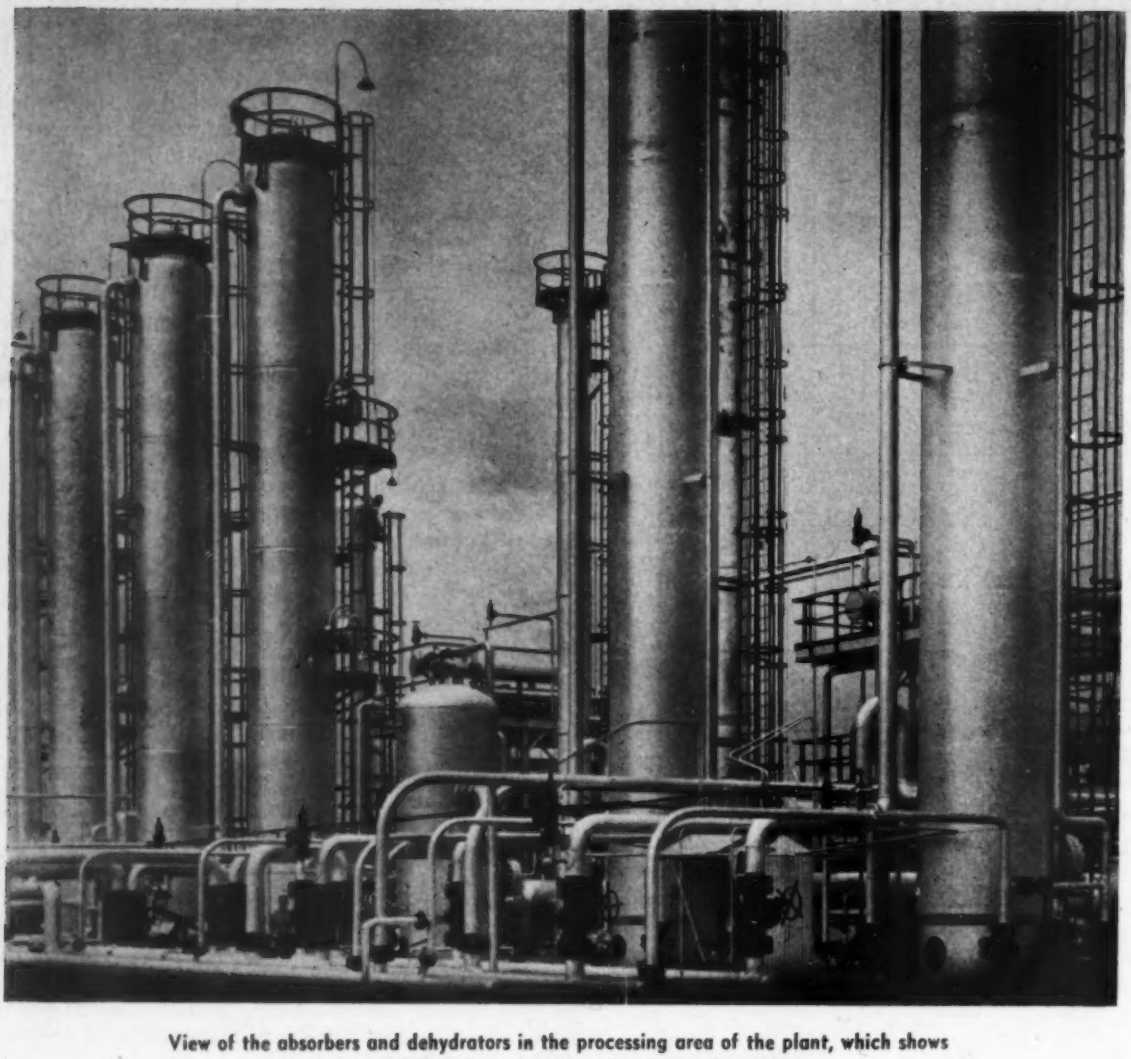
The diameter of the line is increased to 12 inches for the next section. Safety valves on the low-pressure condensate drum, 110 psig setting; hot condensate flash tower, 75 psig; condensate fractionator, 50 psig; low-pressure still, 50 psig; fuel gas header, 50 psig; emergency instrument gas supply, 60 psig; recompressor suction scrubber, 250 psig, and the high-pressure still, 105 psig, are individually connected to the 12-inch section. The recompressor valve set at 520 psig; fuel gas line, 250 psig; recompressor discharge scrubber, 520 psig, and a pressure controlling valve on the recompressor discharge scrubber are connected through a 3-inch manifold to the 12-inch section. Safety valves set at 150 psig on the shell side of the lean oil coolers and the shell side of the lean oil exchangers at 150 psig, tie into a 4-inch header through 3-inch lines, and the valves on the tube side of the rich oil line, set at 200 psig, are connected to the 4-inch header through a 2-inch line. The intermediate condensate flash drum, high-pressure flash drum, and the debutanizer feed drum are equipped with two safety valves per drum, set at 250, 550, and 105 psig, respectively, and are connected to a 12-inch header through 8-inch lines. This header is a branch which is connected to the main 12-inch section. Also connected to the header is a 4-inch line from the safety valve set at 55 psig on the condensate fractionator reflux accumulator, a 2-inch line from a pressure controller also on the accumulator, a 2-inch line from the check valve on the low pressure still reflux accumulator, and a 3-inch line from the safety valve on the high-pressure still reflux accumulator, which has a setting of 125 psig.

Last Section of Flow Line

The last section of the flow line is 16 inches in diameter, which is the size of the line from the plant area to the flare stack. First header from this section is an 8-inch diameter line. Connections to this header are from the knockout drum pressure control valve through an 8-inch line, a 4-inch line from the low pressure rich oil flash tower and reabsorber safety valve set at 75 psig, a 6- and a 4-inch line from valves on the intermediate rich oil flash drum valve set at 250 psig, and a 6-inch line from the high-pressure rich oil flash drum valve set at 550 psig. The depropanizer safety valve, set at 265 psig, vents into a 3-inch line and the reflux accumulator pressure controller vents into a 2-inch line that is connected to the 3-inch. The 3-inch is then connected to the 6-inch line from the deisobutanizer valve set at 140 psig to the 8-inch header. A 2-inch line connects the deisobutanizer pressure controller to the 6-inch from the deisobutanizer. The debutanizer reboiler valve is connected to the 8-inch header by a 3-inch line. Safety valves on the de-ethanizer (500 psig) and debutanizer (300 psig) are connected by 3- and 4-inch lines, respectively, to a 6-inch header and then to the 8-inch header.

Inlet Scrubbers and Absorbers

A 10-inch branch header is used in manifolding the 3-inch lines from the safety valves on the two



View of the absorbers and dehydrators in the processing area of the plant, which shows the accessibility of the location of various safety valves.

main absorbers and the absorber residue scrubber which are set at 1200 psig, 4-inch lines from the valves on the four dehydrators, also set at 1200 psig, reactivating gas preheater, 1200 psig, low-pressure gas heater, 75 psig, and the water separator drum. Dehydrator aftercooler safety valve lines are 1½-inch and connect to the branch header through a 2-inch line. Valve settings are 1200 psig.

Safety valves on the inlet gas scrubbers are connected by a 4-inch line to the 16-inch main flow line. The four safety valves on the inlet gas lines to the scrubbers are connected by 4-inch lines to a 6-inch header to the main flow line. Two of these valves are set at 1190 psig, one at 1195 psig, and the fourth at 1200 psig.

Vented gas from the plant flows through the 16-inch line to the blow down drum for separation of entrained liquids, then through three flame arrestors connected in parallel to the flare stack. A pilot flame is kept burning at the top of the stack, to ignite gas released from the plant. Provision is made for relighting the pilot when it is blown out by high winds.

Liquid Draining System

The original underground drainage system consisted of tile piping; however, due to the high pressures at which the plant operates, it was found advisable to replace the tile with 6-inch steel pipe. Blowing liquids from tanks under pressure often ruptured the tile creating hazardous operating conditions. In order to prevent loss of recoverable hydrocarbon liquids that were drained from the vessels, a drain receiver drum was installed outside the processing area and all liquids flow into the drum. Gas overhead from the drum flows to the flare stack and the bottoms flow to the slop and rerun tanks.

Inlet Scrubber Blowdown

Following several freeze-ups in the field lines to plant, a bleed or blowdown header was installed from the inlet scrubbers direct to the flare stack and to the burning pit for emergency slugging. The freezing of these lines is caused by the formation of hydrates which completely stops gas flow. In order to clear this condition it is necessary to reduce the pressure in the frozen section. When the hydrates or ice particles were broken they caused a great deal of trouble in the plant flash system. As a matter of fact, there was a definite fire hazard, because the drains and other equipment could not handle the excess slugging loads and therefore, caused overflows and excessive pressures. The operation of this new installation has been found to be very satisfactory. Connections are made both in the liquid and vapor spaces of inlet scrubbers, as shown on the diagram, for releasing vapor and liquids simultaneously.

Applications of Thermodynamics to Hydrocarbon Processing

Part IV
THE PERFECT GAS

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THE fundamentals of thermodynamics have been presented in the preceding three chapters. Equations derived from the concepts of conservation and degradation of energy form the basis for developing charts and tables of thermodynamic properties required in making heat, power and equilibria calculations. In hydrocarbon processing such tools are required for other gases as well as hydrocarbons.

Before taking up these applications of thermodynamics to the more complicated systems, the fundamentals will be illustrated by some applications to the classical perfect gas fluid.

Some of these perfect gas equations have applications to actual gases, if the proper coefficients and technique are used.

IN THE study of the behavior of gases and vapors and the application of thermodynamics thereto, it is convenient to have a "perfect" or "ideal" gas to represent limiting conditions, which actual gases may be made to approach. The various thermodynamic equations are much simpler for the perfect gas, thus making it ideal for illustrating the fundamentals of thermodynamics.

At low pressures and/or high temperatures all gases and vapors approach a condition where their P-V-T properties may be expressed by the simple equation

$$PV = RT \qquad (89)^*$$

where the units of R, the gas constant, must be consistent with the units for P, V and T. When PV/T is in heat units, either (Btu)/(lb. mol) (°R) or (gm cal.)/(gm mol) (°K), the value of the gas constant R is 1.987, which is known as the "universal gas constant." With other units of P, V and T, the constant is different as indicated in the following tabulation:

P	V	T	R
atmospheres	cc/gm mol	°K	82.06
lbs/sq.ft.	cu.ft./lb.mol	°R	1544
lbs/sq.in.	cu.ft./lb.mol	°R	10.73

Equation 89 is known as the "perfect gas law equation" and is a combined expression of Boyle's law and Charles' law. Boyle's law states that PV is a constant for a given weight of gas at constant temperature. Charles' law states that volume is proportional to absolute temperature for a given weight of gas at constant pressure. Equation 89 represents the behavior of ideal gases, the limit approached by actual gases. This equation is only an approximation for actual gases.

The approach to ideality depends upon the molecular structure of the gas as well as the pressure and temperature conditions. Smaller molecular weights, lower pressures and higher temperatures all favor closer approach to perfect gas law conditions. This is explained by kinetics: The smaller the molecules relative to the spaces between them (molecule size, temperature and pressure determine this condition), the fewer forces of attraction or repulsion and the closer the approach to the ideal gas relationship.

From the above equation it follows, as will be shown later, that the specific heats, entropy, energy, enthalpy, etc., are functions of temperature and independent of pressure or volume for the perfect gas. Likewise, the Joule-Thomson coefficient is zero for an ideal gas. These conditions are sometimes used in the definition of a perfect gas although they follow from Equation 89.

* Equations marked thus apply to perfect gases only.

Simple equations are derived for the various thermodynamic functions for a perfect gas by obtaining derivatives of pressure and volume from equation 89 and combining with the basic equations from Part III.

Derivatives—The various derivatives required are obtained by differentiating equation 89, giving the following:

$$\left(\frac{\delta P}{\delta T}\right)_v = \frac{R}{V} \qquad (90)^*$$

$$\left(\frac{\delta^2 P}{\delta T^2}\right)_v = 0 \qquad (91)^*$$

$$\left(\frac{\delta V}{\delta T}\right)_P = \frac{R}{P} \qquad (92)^*$$

$$\left(\frac{\delta^2 V}{\delta T^2}\right)_P = 0 \qquad (93)^*$$

These derivaties are used as follows:

Specific Heats—The fundamental equation for the effect of volume on specific heat at constant volume was found to be

$$\left(\frac{\delta C_v}{\delta V}\right)_T = T\left(\frac{\delta^2 P}{\delta T^2}\right)_v \qquad (70)$$

Combining equations 70 and 91, gives the following relation for the effect of volume on the specific heat of a perfect gas at constant volume.

$$\left(\frac{\delta C_v}{\delta V}\right)_T = 0 \qquad (94)^*$$

Likewise, the fundamental equation for the effect of pressure on specific heat at constant pressure is

$$\left(\frac{\delta C_P}{\delta P}\right)_T = -T\left(\frac{\delta^2 V}{\delta T^2}\right)_P \qquad (72)$$

Combining equations 72 and 93, gives the following relation for the effect of pressure on the specific heat of a perfect gas at constant pressure.

$$\left(\frac{\delta C_P}{\delta P}\right)_T = 0 \qquad (95)^*$$

The fundamental equation for the difference in the

specific heats at constant pressure and volume is

$$C_P - C_V = T\left(\frac{\delta P}{\delta T}\right)_V \left(\frac{\delta V}{\delta T}\right)_P \quad (73)$$

Combining equations 73, 89, 90 and 92 gives the following equation for the difference in specific heats for a perfect gas:

$$C_P - C_V = R \quad (96)^*$$

Perfect gas specific heats are independent of pressure or volume, being functions of temperature only. For some perfect gases the specific heats do not change with temperature either.

Energy—The fundamental differential equation for the internal energy

$$dE = C_V dT + \left[T\left(\frac{\delta P}{\delta T}\right)_V - P \right] dV \quad (56)$$

Combining equations 56, 89 and 90, gives the following equation for the internal energy of a perfect gas

$$dE = C_V dT \quad (97)^*$$

which is the same as saying that

$$\left(\frac{\delta E}{\delta V}\right)_T = 0 \quad (98)^*$$

or that the internal energy of a perfect gas is a function of temperature only and independent of volume.

Enthalpy—The fundamental differential equation for the enthalpy is

$$dH = C_P dT + \left[V - T\left(\frac{\delta V}{\delta T}\right)_P \right] dP \quad (65)$$

Combining equations 65, 89 and 92 gives the following equation for the enthalpy of a perfect gas

$$dH = C_P dT \quad (99)^*$$

which is the same as saying that

$$\left(\frac{\delta H}{\delta P}\right)_T = 0 \quad (100)^*$$

or that the enthalpy of a perfect gas is a function of temperature only and independent of pressure.

Joule-Thomson Effect—The general equation for the Joule-Thomson effect is

$$\mu = \frac{T\left(\frac{\delta V}{\delta T}\right)_P - V}{C_p} \quad (66)$$

Combining equations 66, 89 and 92 gives the Joule-Thomson coefficient for a perfect gas as zero.

Entropy—The fundamental differential equation for the entropy is

$$dS = \frac{C_P}{T} dT - \left(\frac{\delta V}{\delta T}\right)_P dP \quad (68)$$

Combining equations 68 and 92 gives the following equation for the entropy of the perfect gas

$$dS = \frac{C_P}{T} dT - \frac{R}{P} dP \quad (101)^*$$

If C_p is constant, as it usually is for a perfect gas

$$S = C_P \ln T - R \ln P + \text{Const} \quad (102)^*$$

From equations 101 and 102 it is obvious that the entropy of a perfect gas is a function of both temperature and pressure. This is not the case for the energy and the enthalpy.

Free Energy—The fundamental equation for the free energy is

$$(\Delta F)_T = F_2 - F_1 = \int_1^2 V dP \quad (85)$$

Combining equations 85 and 89 gives the following equation for a perfect gas

$$\left(\Delta F\right)_T = F_2 - F_1 = RT \int_1^2 \frac{dP}{P} = RT \ln \frac{P_2}{P_1} \quad (103)^*$$

This is a very important equation that will be used later in the development of phase equilibria constants.

Mollier Diagram for Perfect Gas

The change in enthalpy for a given process is frequently required. The process in question may take place at constant pressure, temperature or entropy. In the latter case quantitative values of entropy are not required, it being sufficient to know that the entropy remained constant. Occasionally, differences in entropies are also desired.

Entropies and enthalpies may be tabulated in a form similar to the steam tables or they may be presented in graphical form such as the Mollier diagram. The Mollier diagram (enthalpy vs. entropy) for steam has long been a very useful tool of the engineer. From it changes in enthalpy for isothermal, isobaric, isentropic or reversible changes in state may be found. It is also possible to determine changes in entropy for these same changes in conditions.

Among the many uses of the Mollier diagram for steam are: (1) the calculation of the flow velocity from a nozzle, jet or orifice; (2) the calculation of work absorbed by a turbine wheel, and (3) the calculation of the loss by throttling or wire-drawing. Mollier diagrams for hydrocarbons have many more uses and, of course, are much more complicated because of the complexity of hydrocarbon systems. As part of the illustration of the fundamentals of thermodynamics, a Mollier diagram is developed for a perfect gas.

A perfect monatomic gas is defined by the relations:

$$PV = RT,\ C_P = \frac{5}{2} R, \text{ and } C_V = \frac{3}{2} R;$$

where R is the gas constant. From these definitions and the thermodynamics equations derived above, the preparation of a Mollier diagram for a perfect gas is a simple problem. Such a plot has no border curves (saturated liquid and saturated vapor) and is entirely in the vapor phase. By equation 99 it was shown that the enthalpy of a perfect gas is a function of temperature only, giving

$$dH = C_P dT = \frac{5}{2} R dT$$

integrating

$$\Delta H = \frac{5}{2} R (T - T_o) = 5 (T - T_o) \quad (104)^*$$

where ΔH is the change in enthalpy in Btu/lb. mol between a temperature of T and a reference temperature of T_o, both in degrees Rankine, for all pressures.

The entropy relationship for a perfect gas is not as simple, however, because pressure has an effect so two expressions are required. Starting with equation 101, these expressions are derived. The isobaric effect of temperature on the entropy of a perfect gas is given by the following equation:

$$\Delta S_P = \int \frac{C_P}{T} dT = \frac{5}{2} R \ln \frac{T}{T_o} = 5 \ln \frac{T}{T_o} \quad (105)^*$$

The isothermal effect of pressure on the entropy of a perfect gas is given by the following equation:

$$\Delta S_T = -\int \frac{R}{P} dP = -R \ln \frac{P}{P_o} = -2 \ln \frac{P}{P_o} \quad (106)^*$$

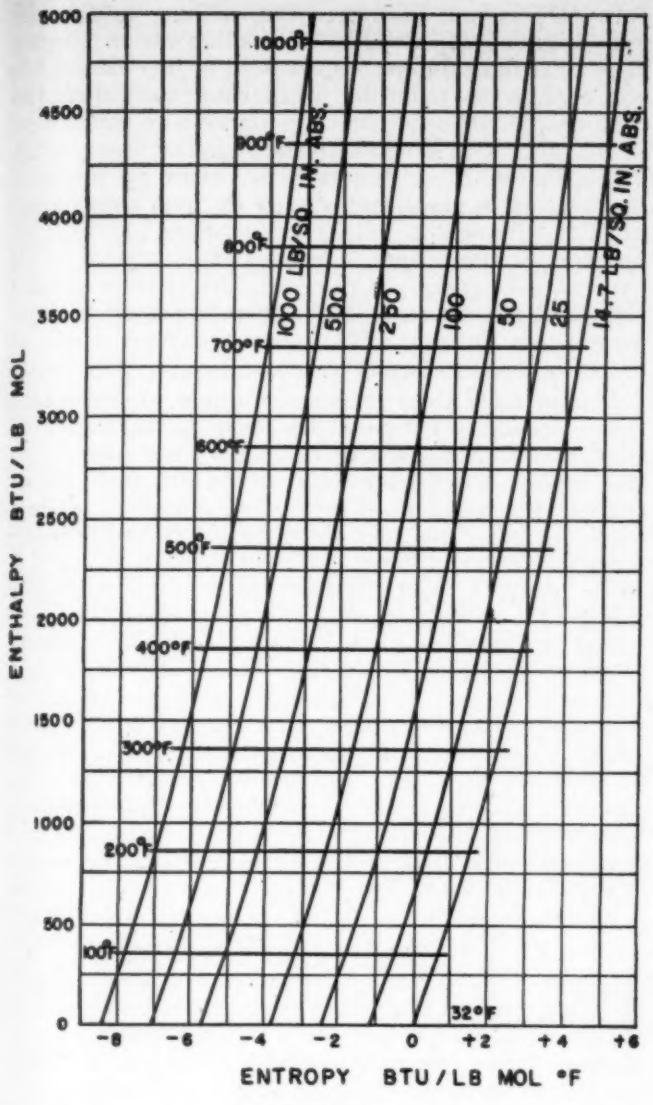

FIGURE 5
Mollier Diagram for Perfect Gas
Entropy-Enthalpy Type.

Combining equations 105 and 106 gives the following equations for the enthalpy of a perfect gas

$$\Delta S = 5 \ln \frac{T}{T_o} - 2 \ln \frac{P}{P_o} \qquad (107)^*$$

where ΔS is the change in entropy in Btu/lb.mol-°R between a temperature of T and a reference temperature of T_o, and between a pressure of P and a reference pressure of P_o, pressures being in pounds per square inch, absolute.

Taking 32° F. and 14.7 psia as the reference point, values of S and H are calculated for a perfect gas and plotted. Sample calculations are given in Table 8. The resulting Mollier Diagrams are shown as Figures 5 and 6, Figure 5 being the Entropy-Enthalpy

TABLE 8
Sample Calculations
Mollier Diagram for Perfect Gas

Enthalpy above 32° F. (at all pressures)

T°F.	T-32	$\Delta H = 5$ (T-32) B.t.u./Lb. Mol.
200	168	840
400	368	1840
600	568	2840
800	768	3840
1000	968	4840

Effect of Temperature on Entropy (at 14.7 psia above 32° F.)

T°F.	T°R.	$\frac{T}{492}$	$\log_{10} \frac{T}{492}$	$\Delta S = (5)(2.3) \log_{10} \frac{T}{492}$ B.t.u./Lb. Mol. °F.
200	660	1.34	0.128	1.475
400	860	1.75	0.243	2.795
600	1060	2.15	0.333	3.83
800	1260	2.56	0.4085	4.70
1000	1460	2.97	0.473	5.44

Effect of Pressure * on Entropy (at all temperatures)

P	$\frac{P}{14.7}$	$\log_{10} \frac{P}{14.7}$	$\Delta S = (2)(2.3) \log_{10} \frac{P}{14.7}$ B.t.u./Lb. Mol. °F.
25	1.7	0.231	1.06
50	3.4	0.532	2.45
100	6.8	0.832	3.82
250	17.0	1.231	5.66
500	34.0	1.532	7.05
1000	68.0	1.832	8.43

* Reference to 14.7 psia.

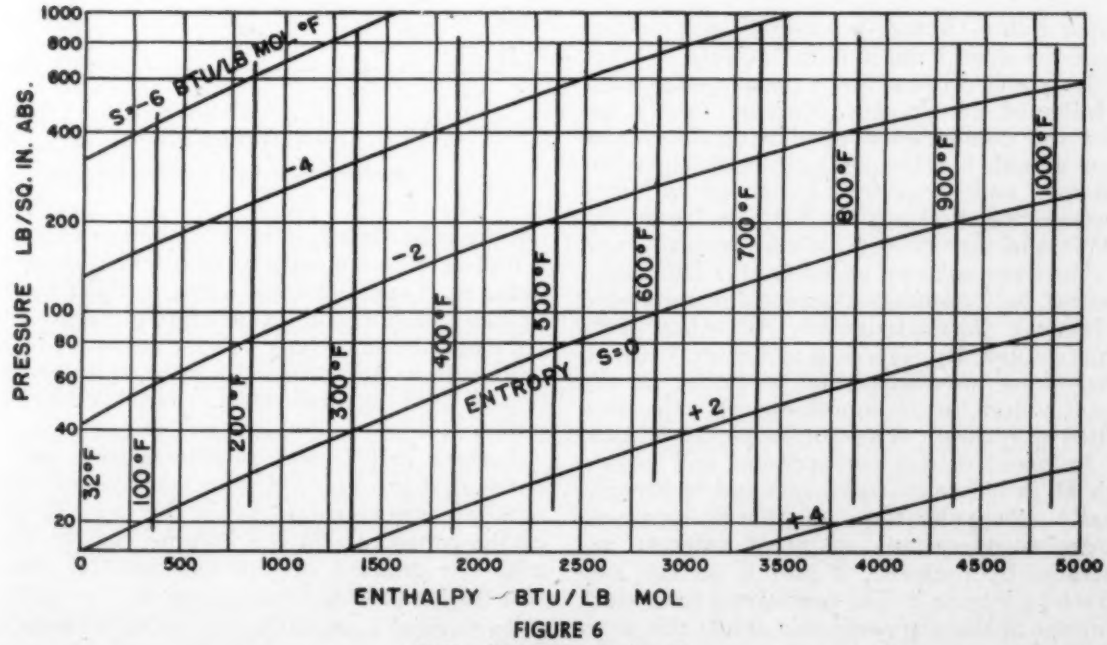

FIGURE 6
Mollier Diagram for Perfect Gas
Pressure-Enthalpy Type.

type and Figure 6 being the Pressure-Enthalpy type of Mollier Diagram.

It is of interest to note that the lines of constant temperature on these Mollier Diagrams for Perfect Gas are straight and show no change of enthalpy as pressure or entropy is changed at constant temperature. This is the most significant difference between the Mollier diagram for a perfect gas and an actual gas.

Compression Equations for Perfect Gas

Although gas compression is one of the most frequently occurring thermodynamic operations in the processing of hydrocarbons, the methods employed in making compression calculations have not kept up with improvements and advances made in other calculation methods for hydrocarbon systems. There is a widespread practice of using equations based on the perfect gas law with empirical or rule-of-thumb coefficients for computing work, temperature rise and capacity for hydrocarbon gas compressors. It is well recognized that these methods are definitely limited in usefulness and accuracy. The use of such methods has come about through a lack of any better method as well as the inadequacy of the data available on the behavior of hydrocarbons and their mixtures. Better methods can now be developed by applications of some of the recent advances made in hydrocarbon thermodynamics. The form of these new methods and the development procedures are indicated by a few recent contributions that have appeared in the technical literature on this subject.

Improved methods of hydrocarbon-gas-compression calculations will be the subject of a later part of this series. As a background for the study of hydrocarbon-gas compression and as a classic example of the applications of thermodynamics, the compression of the perfect gas will be treated at this point. Although the perfect gas is a special case and not encountered in actual practice, it is convenient to study compression from this point of view first as the perfect gas represents an extreme or limit in the fluid characteristics. Also many of the perfect gas compression equations form the basis for the empirical methods for calculating hydrocarbon-gas compression.

Compression Paths—Before proceeding with the development of the equations, it is of interest to refer to Figure 7, which shows the various paths that might be followed on Pressure-Volume (P-V) coordinates in the compression or expansion of any gas, ideal or actual. On this plot the isobaric (constant pressure) and isometric (constant volume) paths represent the extremes. In between these extremes the isothermal (constant temperature) and isentropic (constant entropy or reversible adiabatic) paths represent the two most frequently encountered paths in classical thermodynamics. All other paths are called polytropic. By referring to Figure 7, it can be seen that there are three areas or zones on the P-V diagram where the compression or expansion path is called polytropic. The polytropic path most frequently followed in gas compression and expansion is path D, in between isothermal and isentropic. In practically all applications of thermodynamics, the compression operations of most interest are those illustrated by paths C, D and E on the P-V diagram given in Figure 7. The isothermal path work is the minimum of these three paths, while the work for the isentropic path is the maximum.

Compression along the intermediate polytropic path (D) is one of decreasing entropy and is the path followed when the jacket-cooling water removes more heat than the heat equivalent of the friction but not enough to maintain isothermal conditions. In compression it is desirable to remove as much heat as is practical to keep the work required down, while in expansion it is desirable to retain as much of the heat as is practical to keep the work developed up. For this reason path D is of more practical interest than the others. This is particularly true for hydrocarbon gases. In practice compressors operate with a slight decrease and expanders with a slight increase in entropy. The same equations apply to both operations, however.

It is of more than academic interest to understand the relationship between the seven paths shown on Figure 7. It is helpful to consider these paths from the standpoint of heat input or output during frictionless compression. The following applies to compression only, the heat flows being in the opposite direction for expansion. For path E, no heat is added to or removed from the gas. Heat is removed from the gas for paths A through D, the amount removed being smallest for path D and largest for path A.

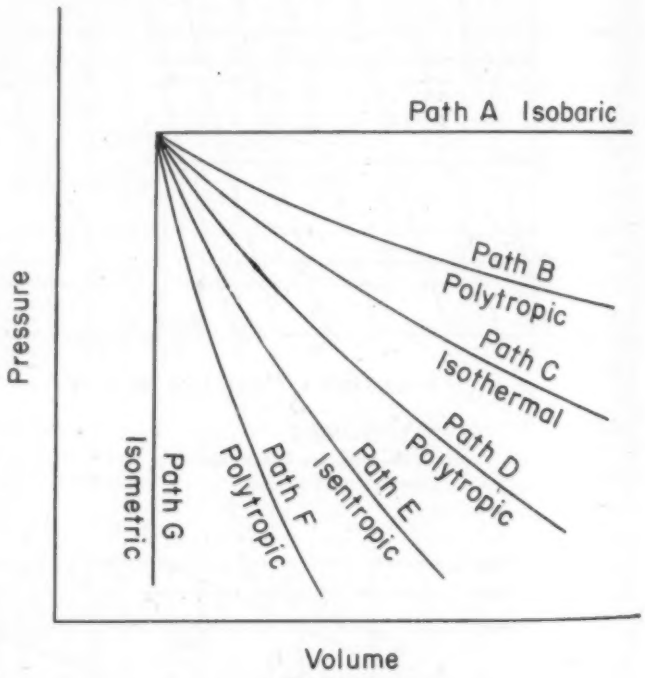

FIGURE 7

PV Paths for Various Compression Paths

On the other hand, heat is added to the gas in paths F and G. The amounts of heat added or removed for paths A, C and G are sufficient to make the operation isobaric, isothermal or isometric, respectively. The amounts added or removed for paths B, D and F are sufficient to determine the polytropic paths relative to the isobaric, isothermal, isentropic and isometric paths.

Isobaric and Isometric—The isobaric and isometric changes require no formulae for work of compression or expansion calculations, as the work is the product of the pressure and the volume change for path A, and the product of the volume and the pressure change for path G.

Isothermal Compression—For an isothermal change of a perfect gas shown by path C, the compression and expansion work equation is very simple due to

the fact that the internal energy of a perfect gas remains constant with changes in pressure and volume. With constant internal energy $Q = W_B$ (see Equation 7) and by definition

$$W_B = \int_2^3 PdV \qquad (108)^*$$

Where point 2 is at the higher pressure (and lower volume) see Figure 8. Substituting for P the perfect gas equivalent from Equation 89 and integrating gives

$$Q = W_B = RT \ln \frac{V_2}{V_1} \qquad (109)^*$$

at constant temperature for a perfect gas $\frac{P_1}{P_2} = \frac{V_2}{V_1}$

Substituting in Equation 109

$$Q = W_B = RT \ln \frac{P_1}{P_2} \qquad (110)^*$$

For isothermal compression $W_F = W_B$, since $\Delta(PV)$ is zero. The use of this equation will be demonstrated in an example later in this article. The results will be in the units of RT, which may be metric or engineering units for heat or work.

Adiabatic Coefficient—Equations will now be derived for adiabatic compression of perfect gas. The equations for polytropic compression of perfect gas are the same as the adiabatic equations but with a different coefficient by definition. Compression may be adiabatic if the jacket-cooling water removes just the heat of friction and no more or no less. Compression can be adiabatic without being isentropic (constant entropy) or reversible, although the operations referred to as "adiabatic" in gas compression parlance are essentially isentropic and reversible.

An important relation will now be derived. If no heat is added to or removed from a perfect gas during compression, $Q = 0$ and $W_B = -dE$ by Equation 7. In this operation the temperature will change. For a perfect gas E is a function of temperature alone (see Equation 97). For an adiabatic process Equation 48 becomes $dE = -PdV$. For a perfect gas $dE = C_v dT$. Combining these two expressions,

$$PdV = -C_v dT \qquad (111)^*$$

Substituting for P from the perfect gas law equation (89)

$$\frac{RT}{V} dV = -C_v dT \qquad (112)^*$$

or

$$R d\ln V = -C_v d\ln T \qquad (113)^*$$

For the case where C_v is constant

$$d\ln V^{(R/C_v)} = -d\ln T \qquad (114)^*$$

On integrating

$$TV^{(R/C_v)} = \text{constant} \qquad (115)^*$$

Since $R = C_p - C_v$

$$TV^{\left(\frac{C_p - C_v}{C_v}\right)} = TV^{\left(\frac{C_p}{C_v} - 1\right)} = \frac{TV^{C_p/C_v}}{V} = \text{constant} \qquad (116)^*$$

From Equation 89, $\frac{T}{V} = \frac{P}{R}$

Substituting in Equation 116 gives

$$PV^{(C_p/C_v)} = R \times \text{constant} = \text{constant}$$

The ratio C_p/C_v is given the symbol γ for convenience. For the adiabatic compression of a perfect gas

$$PV^{\gamma} = C \qquad (117)^*$$

For the polytropic compression of a perfect gas, the path may be approximated by

$$PV^n = C \qquad (118)^*$$

where n is a constant coefficient for any given path.

For path D the value of n will be greater than 1.0 but less than γ.

Although these equations were developed for a perfect gas, it has been found that they fairly adequately define the pressure-volume relations for some conditions with most non-ideal vapors, when an empirical coefficient, determined by experiment, is used.

Single-Stage Adiabatic Compression—The equation for the theoretical work done in single-stage adiabatic (and isentropic) compression on a perfect gas will be

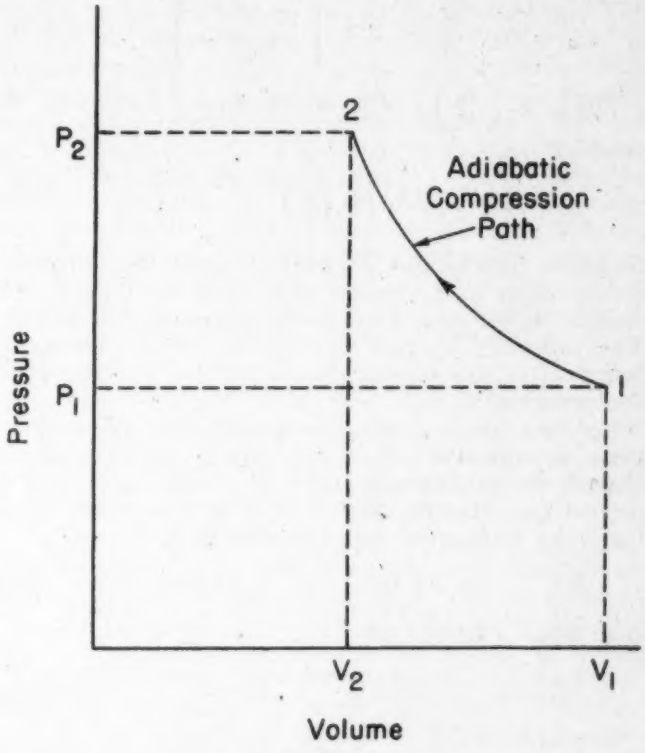

FIGURE 8
PV Diagram for Single-Stage Adiabatic Compression

developed by reference to Figure 8. In compressing from point 1 to point 2, the theoretical work will be

$$W = \int_1^2 VdP \qquad (119)$$

For a perfect gas

$$PV^{\gamma} = \text{constant} \qquad (118)^*$$

from which it follows that

$$P^{1/\gamma} V = P_1^{1/\gamma} V_1 = P_2^{1/\gamma} V_2 = \text{a constant (differing from the constant in Equation 118 by a constant factor)} \qquad (118A)^*$$

Combining Equations 118A and 119 and eliminating the term V,

$$W = C \int_1^2 (P)^{-\frac{1}{\gamma}} dP \qquad (120)^*$$

Integrating

$$W = \frac{C}{1 - \frac{1}{\gamma}} \left[P_2^{\left(1 - \frac{1}{\gamma}\right)} - P_1^{\left(1 - \frac{1}{\gamma}\right)} \right] = \frac{CP_2^{\left(1 - \frac{1}{\gamma}\right)} - CP_1^{\left(1 - \frac{1}{\gamma}\right)}}{1 - \frac{1}{\gamma}} \qquad (121)^*$$

Eliminating C in Equation 121 by substituting for it $P_1^{\frac{1}{\gamma}} V_1$ and $P_2^{\frac{1}{\gamma}} V_2$ in accordance with Equation 118A.

$$W = \frac{P_2^{\frac{1}{\gamma}} V_2 P_2 \left(1 - \frac{1}{\gamma}\right) - P_1^{\frac{1}{\gamma}} V_1 P_1 \left(1 - \frac{1}{\gamma}\right)}{\frac{\gamma - 1}{\gamma}} = \left(\frac{\gamma}{\gamma - 1}\right)[P_2V_2 - P_1V_1] \quad (122)^*$$

or

$$W = \frac{\gamma}{\gamma - 1} P_1V_1 \left[\frac{P_2V_2}{P_1V_1} - 1\right] \quad (123)^*$$

But $\frac{V_2}{V_1} = \left(\frac{P_1}{P_2}\right)^{1/\gamma}$ with which Equation 123 may be simplified to

$$W = \frac{\gamma}{\gamma - 1} P_1V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} - 1\right] \quad (124)^*$$

Equation 124 is the theoretical work for adiabatic compression of a perfect gas. As it is written, the work is in the same units as the pressure and volume. The units P, V, and W will be clearly indicated below after developing the equations for two-stage compression.

Before taking up the two-stage-compression equations, an equation will be derived for the temperature change in single-stage adiabatic compression of a perfect gas. Starting with Equation 116 and eliminating V by the perfect gas law equation

$$TV^{\gamma - 1} = T\left(\frac{RT}{P}\right)^{\gamma - 1} = \text{constant} \quad (125)^*$$

from which it follows that

$$\frac{T^{\gamma}}{P^{\gamma - 1}} = \frac{T_1^{\gamma}}{P_1^{\gamma - 1}} = \frac{T_2^{\gamma}}{P_2^{\gamma - 1}} = \text{constant} \quad (126)^*$$

Solving for T_2

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} \quad (127)^*$$

Multiple-Stage Adiabatic Compression — The equations for the theoretical work and temperature rise for multiple-stage adiabatic (and isentropic) compression of a perfect gas with cooling to the original temperature between stages and with equal work for each stage can be developed from the above equations by reference to Figure 9. The PV diagram given in Figure 9 represents the path for two-stage compression with intercooling. The two-stage equations will be derived first and then the multistage equations written by analogy from the one- and two-stage equations.

If the conditions at the start of the second stage are designated by primes, i.e., P′, V′ and T′, so that $T_1 = T'$ (see Figure 9) and $P_1V_1 = P'V'$, the work for each stage may be written by inspection, using Equation 124 as a guide.

$$W_1 = \frac{\gamma}{\gamma - 1} P_1V_1 \left[\left(\frac{P'}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} - 1\right] \quad (128)^*$$

$$W_2 = \frac{\gamma}{\gamma - 1} P_1V_1 \left[\left(\frac{P_2}{P'}\right)^{\frac{\gamma - 1}{\gamma}} - 1\right] \quad (129)^*$$

The total work for two-stage compression is obtained by adding Equations 128 and 129

$$W = W_1 + W_2 = \frac{\gamma}{\gamma - 1} P_1V_1 \left[\left(\frac{P'}{P_1}\right)^{\frac{\gamma - 1}{\gamma}} + \left(\frac{P_2}{P'}\right)^{\frac{\gamma - 1}{\gamma}} - 2\right] \quad (130)^*$$

The total work is a minimum when

$$\left(\frac{P^2}{P'}\right)^{\frac{\gamma - 1}{\gamma}} + \left(\frac{P'}{P_1}\right)^{\frac{\gamma - 1}{\gamma}}$$

has a minimum value. Differentiating with respect to P′, which is the only variable and setting the derivative equal to zero gives

$$P' = \sqrt{P_1P_2} \quad (131)^*$$

Combining Equations 130 and 131 gives

$$W = \frac{2\gamma}{\gamma - 1} P_1V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{2\gamma}} - 1\right] \quad (132)^*$$

From this equation and the previous equations for single-stage compression, the general expressions for the theoretical horsepower and the temperature rise for multiple-stage compression of a perfect gas

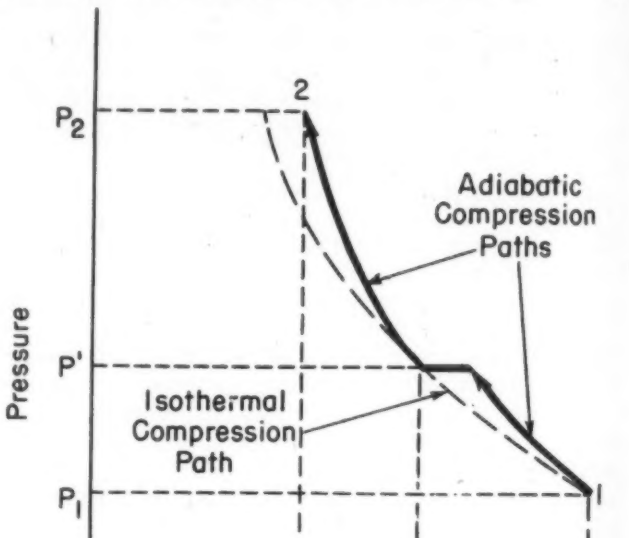

FIGURE 9
PV Diagram for Two Stage Adiabatic Compression

with intercooling to the original temperature and with equal work per stage may be written by inspection

$$HP\ (theo) = \frac{144}{33000} P_1V_1 \frac{S\gamma}{\gamma - 1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{S\gamma}} - 1\right] \quad (133)^*$$

and, in similar manner

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{S\gamma}} \quad (134)^*$$

where: P_1 and P_2 are the intake and discharge pressures in lbs./sq. in. abs.

T_1 = intake temperature, °F abs.
T_2 = discharge temperature, °F abs.
V_1 = cu. ft. per min. of gas at P_1 and T_1
$\gamma = C_p/C_v$, for isentropic compression
S = Number of stages (with intercooling back to initial temperature between stages)

Comments on the use of these equations will follow the development of the volumetric efficiency equation.

Volumetric Efficiency—An actual compressor must have clearance between the end of the piston travel and the cylinder head. The gas remaining in this

clearance space expands on the return stroke of the piston thus partially filling the cylinder and reducing the volume of fresh gas that can be taken in during the intake stroke. The volumetric efficiency is the ratio of the intake volume of gas to the piston displacement, both on the same time basis. This efficiency is a function of the compression ratio, the percent clearance volume, and the coefficient of compression and expansion of the gas involved. An expression for the volumetric efficiency of a perfect gas is derived as follows:

let

V_d = displacement volume
V_c = clearance volume
V_e = volume to which clearance volume gases expand
$C = \frac{V_c}{V_d}$ = ratio of clearance to displacement volumes.

The following relation applies for the adiadatic compression of a perfect gas

$$\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}$$

Using this relationship and the above definitions

$$V_e = V_c\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} = CV_d\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} \qquad (135)^*$$

Actual volume of gas intake

$$V_d + V_c - V_e = V_d\left[1 + C - C\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}\right] \qquad (136)^*$$

from which the volumetric efficiency becomes

$$E_v = \left[1 + C - C\left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}\right] \qquad (137)^*$$

Equation 137 is for single stage compression. The volumetric efficiency for multistage compression should be computed separately for each stage, using this equation.

Uses and Limitations of Equations—All of the above equations have been developed for specified conditions, namely: the isentropic or reversible adiabatic compression of a perfect gas, with intercooling between stages to initial temperature and with the interstage pressure fixed so as to give the minimum total work. This way of defining the interstage pressure is equivalent to saying "equal work per stage." It is well recognized that these equations have wide applications. In this connection it is well to point out their limitations as well.

Other applications which may be made of these equations are: (1) expansion as well as compression, (2) polytropic as well as adiabatic paths, and (3) actual gases as well as perfect gas. The latter involves definite limitations. It is not necessary to say much about the use of these equations for the calculation of expansion operations, which are simply the reverse of compression.

With regard to other paths, these equations may be applied equally well to polytropic compression of a perfect gas where the coefficient is other than C_p/C_v. If the value of the exponent γ in Equation 117 or 118 is not equal to the ratio of specific heats and is not unity, zero or infinity, the resulting path is known as polytropic compression or expansion and the coefficient is designated as n. Table 9, which refers to the various paths shown in Figure 7, describes the various paths, and gives the value of the coefficient for the Equations 117 or 118 for each path.

In this table $\gamma = C_p/C_v$. The exponents are defined by Equations 117 and 118 but it is to be understood

TABLE 9

Descriptions and coefficients for paths on Figure 7

Path	Description	Value of Coefficient
A	Isobaric	0
B	Polytropic	$1 > n > 0$
C	Isothermal	1.0
D	Polytropic	$\gamma > n > 1.0$
E	Isentropic	γ
F	Polytropic	$\infty > n > \gamma$
G	Isometric	∞

that they are for use in Equations 133, 134 and 137. It will be noted that the exponents of P_2/P_1 in Equations 133 and 134 is not a real number for a unity value of n, meaning path C. It will also be noted that this exponent becomes negative for values of n between unity and zero. Accordingly, these equations cannot be used very conveniently for paths B and C. Paths A and G are of academic interest only and path F is not of much practical interest, because it is not customary to add heat while compressing or remove heat while expanding a gas. This leaves paths D and E as the ones of most interest as far as the use of these compression and expansion equations.

For gas expansion, path F is analogous to path D for compression. This analogy implies the removal of a small amount of heat during compression via path D and the addition of a small amount of heat during expansion via path F.

Under some conditions the above perfect gas compression equations may be applied to actual gases. Some of the considerations involved in these applications will be mentioned. One of the most obvious points is condensation after intercooling in multistage compression. With perfect gases, no condensation is always assumed. Actual gases, such as hydrocarbons and refrigerants are frequently near the condensation point while being compressed. In these services the multi-stage equations can not be used. Each stage must be calculated separately.

Probably the most important consideration concerning the application of these equations to actual gases, such as hydrocarbons, is the coefficient, γ. It is not theoretically correct to use the values of C_p/C_v for the gas in question, although this practice will often give results that are satisfactory. Too often this practice gives a higher horsepower answer than is actually required. This can be avoided by using an empirical coefficient for the gas. This empirical coefficient may be determined by experiment or by entropy calculations, the results from either technique being valid only for the range of pressure and temperature covered. The procedure followed in the entropy technique will be discussed in more detail in a later part of this series. At this point it is sufficient to indicate the important features of the calculations, which are: (1) estimating the final temperature after isentropic compression by means of a T-S (temperature-entropy) diagram for the gas concerned and covering the range involved, and (2) estimating the coefficient by Equation 127, using the initial and final temperatures.

The coefficient that appears in the handbooks for ammonia was probably estimated in this way, judging from the excellent agreement between the work calculated by means of the perfect gas compression with the coefficient and the work estimated from the Mollier diagram.

[End of Part IV; Part V will appear in the next issue.]

A Refiner's Look At Gasoline Quality*

A. P. FRAME
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YOU have heard of the man who continually beat himself about the head with a club and explained his actions by saying that it felt so good when he stopped. I think we, in the refining industry, have much in common with that man since we have for years been beating ourselves with the club of ever-increasing gasoline quality but we have not yet, of our own volition, stopped this beating to see if it would feel good or not.

In order to establish a firm position for our peek into the future of gasoline quality it is advisable to carefully survey what has happened in the past. Prior to World War II gasoline quality, particularly from an anti-knock standpoint, improved steadily averaging an increase of slightly more than one octane number per year. Concurrently with this increase in gasoline quality there was a steadily decreasing refinery price for gasoline. As refiners I need scarcely point out that increased gasoline quality costs money, real money; so there must be some reasonable explanation of this phenomena of increasing quality and lower price. I believe this reasonable explanation to be that there was a steadily increasing volume of gasoline business over this period. Increased volume of business in a refinery means lower unit costs so that what has happened in the past is that the reduction in unit costs, due to increased volume of business, has been passed on to the consumer in the form of higher quality and lower price.

There can be no question as to what did happen in the past in regard to gasoline quality but the "why" it happened is not quite so clearly apparent. To the layman it might appear that the gasoline quality was improved to meet the more stringent requirements of the automotive engines being produced, a most logical explanation except that it isn't true. It is a matter of fact that the refining industry has consistently been producing a higher quality gasoline than required for the satisfactory and efficient operations of the cars being currently produced. As a matter of fact, this could scarcely be otherwise because no automotive company would wish to produce and market a car which could not perform satisfactorily on the quality of gasoline generally available. In the isolated cases where this was tried by the automotive industry the results were most unpleasant, both for the automobile company and for the petroleum industry.

The quality of gasoline has been determined by the refining industry itself and then the automotive engineers have designed their engines to utilize this fuel. I can see no reason why this situation will not continue for the future but I still have offered no explanation as to why the petroleum industry historically has consistently raised the quality of gasoline. The answer is apparent to all of you, namely, the free play of competitive forces. Each gasoline marketer in his drive to obtain his share, or more than his share, of the increasing gasoline market has insisted on higher and higher quality to use as bait to get this business, aided and abetted by the fact that there always is a small percentage of cars on the road sufficiently out of adjustment or with a sufficient accumulation of carbon to require for satisfactory performance a higher quality gasoline than that for which it was originally designed.

Gasoline quality in the past has been increased whenever a sufficient number of refiners were able to increase such quality and the respective marketing departments associated with the refiners in this country have been the spur which has driven refinery engineers and technicians to develop and design new and improved refinery processes for the production of higher quality gasolines to be sold at lower and lower prices. Fortunately for this progress—and progress it is—the increasing volume of business has made this anomalous situation economically sound and it has redounded to the welfare not only of the petroleum industry but also to the automotive industry and to the public. Be that as it may, I firmly believe that the past quality of gasoline has been determined *solely* by the refining industry itself and since all forecasts we have as to future gasoline consumption in this country indicate that we may expect this trend of increasing volume of business to continue, I also firmly believe that the gasoline quality of tomorrow will be determined by the refiners of tomorrow.

If this is a sound premise it would appear that refiners in general, as well as automotive engineers, will be interested in any effort to forecast what gasoline quality the refiner of tomorrow will be producing. This is a particularly propitious time, albeit a difficult one, to make such a forecast because we have just came through a war period in which gasoline quality was under the control of government officials and subordinated to the prior needs of the military forces; it was a period in which more than $1 billion was spent in refining facilities for the production of higher quality gasolines; it was a period in which the buying habits of

* This paper, which created considerable discussion, was read at the American Petroleum Institute, Refining Division meeting, in June, 1947, at St. Louis. Answers by Davis Read and George Kelso follow Mr. Frame's article on pages 111 and 112 respectively.

The author, a B.S. graduate (1921) of Dalhouse University, Halifax, N. S., worked for three years as test engineer in a natural gasoline organization before joining Cities Service Oil Company as plant engineer at Ponca City, Okla. He later became superintendent of the same company's Petty's Island plant and in 1938 was named assistant refinery director, New York. In 1942 he became vice president and chief engineer of Cities Service Refining Corporation which built and operates the Lake Charles, La., refinery and butadiene plant. He was with PAW during the war but in October, 1945, returned to Cities Service as vice president and director of the manufacturing and research division.

the customer were radically changed as evidenced by the greatly increased percentage of premium gasoline now being consumed.

Following the war, which to some extent we are still going through, a period in which the limitations on the use of lead tetraethyl and the control of gasoline quality have prevented the free play of those forces which controlled gasoline quality prior to the war. It would therefore appear that if it is possible today to make a reasonable forecast of what tomorrow's refinery will be and will do, the results might be valuable and interesting.

So far we have discussed generally the antiknock properties of gasoline but if this forecast of future gasoline quality is to be of value to the refining industry and automotive engineers, it should include probable trends in boiling range as well as the chemical composition of tomorrow's gasoline.

Permit me to synthesize a typical modern refinery of 1938. This typical refinery had a balanced crude capacity of 75,000 barrels per day of average Mid-Continent crude. Its process facilities would consist of crude topping units, capable of cutting 300° end point straight run gasoline; a reforming naphtha cut from 300 to 400°; a kerosine stream; a straight run distillate fuel oil stream, and a light and heavy gas oil side stream for thermal cracking unit charge. The bottoms of the crude units would go to a vis breaker under recycling conditions for the production of heavy fuel oil and additional cracker charging stock. The thermal cracking equipment would consist of a thermal reforming unit and gas oil thermal cracking units of a capacity to permit of recycling to extinction. There would also be a catalytic polymerization unit for the conversion of butylenes and propylenes to motor gasoline. This refinery would produce yields of products as shown in Table 1.

Yields have been set so that the kerosine yield and the yield of distillates (as 100 percent straight-run product) approximate the national average yields for 1938. Yields of other products have been calculated on the basis of the most efficient operation of the process facilities already described.

In determining the quality of the gasoline from this 1938 refinery, it has been assumed that the premium-grade gasoline production amounts to 10 percent of the total gasoline production (the national average was slightly over seven percent for 1938). It has furthermore been assumed that this refinery, being completely modern as of 1938, would be producing gasolines one octane number higher than the national average for this period so that the amount of lead tetraethyl shown in the inspections is that amount necessary to meet these specified octane numbers. With these assumptions the quality of gasolines from the 1938 refinery would be as shown in Table 2.

On the basis that this hypothetical refinery was completely modern as of 1938 from a processing standpoint, it has not been assumed that this refinery would then have been producing gasoline quality up to the absolute limit of its ability as evidenced by the fact that the lead content as shown on the inspections is relatively low. Those refineries in 1938 which were not so well equipped with modern processing facilities would, and did, require the use of greater quantities of lead tetraethyl to meet competitive gasoline quality. Nevertheless I believe it to be true that the 1938 quality of gasoline was fundamentally set by refineries having process facilities similar to those described for our hypothetical plant.

TABLE 1
1938 Refinery Yields

PRODUCT	Percent Yielded
Gasoline	53.8 (68.3 ASTM Oct. No. Clear)
Kerosine	5.5
Distillates	13.0
Residual fuel oil	23.5
Gas and loss	4.2
Total	100.0

TABLE 2
1938 Refinery Gasoline Quality

	Regular Grade	Premium Grade
10 percent Evaporated °F	125	125
50 percent Evaporated °F	212	195
90 percent Evaporated °F	340	300
End point	400	400
Vapor pressure (lbPSI)*	10	10
Octane number—ASTM	72	79
Octane number—Research	77	84
TEL (cc's per gallon)	0.3	1.0
Hydrocarbon Analysis:		
Percent Paraffinic	55.0	53.0
Percent Naphthenic	13.0	6.0
Percent Aromatic	16.0	9.0
Percent Olefinic	16.0	32.0

* Regular grade gasoline requires 2.3 percent extraneous butane to meet vapor pressure.

If it is possible for us to estimate what probably would have happened to this typical 1938 refinery because of the war and the postwar situation it should be possible to forecast what quality gasoline this refinery will be making in 1950 and if our forecast includes what actually has happened and will happen to a sufficient number of existing refineries we should be able to calculate the quality of gasoline that will be produced in 1950 always assuming that the necessary assumptions prove to be correct. Of the factors caused by the war which will influence our hypothetical refinery, the following are most important:

(1) The daily national average refinery crude runs in 1938 were 3,192,000 barrels. In 1950 it has been estimated that they will approximate 5 million barrels per day. Therefore, we can assume that the crude run of our hypothetical refinery by 1950 will have increased from 75,000 to 100,000 barrels per day.

(2) During the war catalytic cracking units were built, having a total virgin gas oil charging capacity of 750,000 barrels per day. Since war's end catalytic cracking units with a capacity of more than 250,000 barrels per day of virgin gas oil have been projected, on a definite basis. Considering prewar catalytic cracking capacity, present indications are that by 1950 there will be in operation catalytic cracking units with a total charging capacity of approximately 1.2 million barrels per day. This capacity should be sufficient to handle all available straight-run gas oil from about 60 percent of the total crude that is estimated will be run at refineries in 1950. For this reason we can assume that our hypothetical refinery, being desirous of maintaining its relative 1938 position, will have sufficient catalytic cracking units in operation to handle all available straight-run feed stock on a once-through basis. Furthermore, our hypothetical refinery, un-

doubtedly would have installed during the war alkylation capacity up to the limit of olefin availability. It is probable that the 1950 operation of these alkylation facilities will only be at a fraction of their wartime production capacity.

(3) A real effect on the 1950 gasoline quality picture will be the percentage of premium gasoline required to meet consumer demand. Any company which prewar sold 10 percent of its total gasoline production in the form of premium gasoline was definitely higher than average. During the war, because of gasoline rationing and degradation of general gasoline quality, consumers clamored for ever-increasing amounts of premium-grade gasoline, so much so that in the interest of conservation of tetraethyl lead it was necessary to limit production of premium gasoline. Today, perhaps because of a wartime carryover, the demand for premium gasoline is about 40 percent of the total gasoline production.

Why the Demand for Premium

This high percentage demand for premium gasoline likely will not continue at its present high ratio. An appreciable amount of this high demand for premium gasoline probably is caused by people, in general, having money and people assuming that whatever costs more is necessarily better for their use. In certain sections where the general level of prosperity has been lowered locally, due to prolonged strikes, etc., there has been a pronounced decrease in the demand for premium gasoline although the total gasoline demand in these areas has not been appreciably affected. Of more particular interest is the fact that when the local situation has been corrected and normal prosperity restored to the area the percentage demand for premium gasoline has not returned to its previous high level. I believe that when the flush of wartime savings is dissipated and the general availability of consumer goods becomes greater, the increased competition for the lesser number of consumers' dollars will result in a definite decrease in the demand for premium-grade gasoline. For this reason I have assumed that the amount of premium gasoline production from our hypothetical refinery in 1950 will be 25 percent of its total gasoline production, this percentage being midway between the 1938 percentage and that existing today.

Using the basis just outlined I have therefore assumed that our hypothetical refinery in 1950 would be processing 100,000 barrels per day of the same type crude which it was processing in 1938. I have assumed this refinery to have process facilities consisting of crude topping units, capable of cutting 300 end point straight run gasoline; a reforming naphtha cut from 300 to 400°; a kerosine stream; straight-run diesel fuel stream, and a gas oil side stream for catalytic cracking unit charge. I have assumed that the bottoms of the crude units would go to a vis breaker operating on a once-through basis for the production of heavy fuel oil and additional cat cracker charge, the catalytic cracking units to have sufficient capacity to charge all the straight run gas oil with the exception of the diesel fuel stream. The thermal cracking capacity to consist of a thermal reforming unit and capacity for cracking that portion of the catalytic cycle stock not suitable for heating oil. It is also assumed that the catalytic polymerization unit would be operated to the same capacity as in 1938 producing propylene and butylene polymer and that the alkylation facilities, installed during the war, would be operated to balance the vapor pressure of the gasoline assuming that the same total volume of extraneous butanes as used in 1938 would be available to the refinery. On such a basis the product yields would be as shown in Table 3.

TABLE 3
1950 Refinery Yield

PRODUCT	Percent Yielded
Gasoline	58.3 (72.9 ASTM Octane No. Clear)
Kerosine	5.5
Diesel fuel	3.5
Distillate fuel	16.0
Residual fuel	10.9
Gas and loss	5.8
Total	100.0

When these 1950 yields are compared with the 1938 yields as shown in Table 1 it is interesting to note that the 1950 percentage yields of gasoline and distillate fuels, excluding kerosine, have increased by 8 percent and 50 percent respectively; that the kerosine percentage yield is unchanged and that the percentage yield of residual fuel has decreased by 54 percent. If the yield comparison is made on the total volume production our 1950 hypothetical refinery would produce in barrels 44 percent more gasoline, 33 percent more kerosine, 100 percent more distillate fuels and 38 percent less residual fuel. The 1950 percentage yields thus represent an increase of about $.11 per barrel of crude in the total value of refined products yielded than do the 1938 yields based on today's price structure.

The purpose of this paper is to try to estimate future gasoline quality and that is most certainly a broad enough field. However, future gasoline quality cannot be calculated, from a refinery standpoint, without making certain assumptions as to the future quality of other products, primarily distillate fuel oils. In our calculations as to the yields and qualities of our 1950 refinery it has been assumed that the production of diesel fuel oil would be a 100 percent straight-run product and that the yield of domestic heating oils would be 100 percent catalytically cracked material with the exception of the addition of sufficient straight-run naphtha to meet the front end boiling range specifications. This method of refining operation appears to be a neces-

TABLE 4
1950 Refinery Gasoline Quality

	Regular Grade	Premium Grade
10 percent Evaporated °F	125	125
50 percent Evaporated °F	210	200
90 percent Evaporated °F	350	325
End point	425	400
Vapor pressure (lbPSI)*	10	10
Octane number—ASTM	79	84
Octane number—Research	85	94
TEL (cc's per gallon)	1.1	1.0
Hydrocarbon Analysis:		
Percent Paraffinic	45.0	32.0
Percent Naphthenic	12.0	2.0
Percent Aromatic	23.0	16.0
Percent Olefinic	20.0	50.0

* Regular grade gasoline requires 1.9 percent of extraneous butane to meet vapor pressure.

sity if both expected gasoline quality and volume of heating oil distillates are to be obtained. I recognize that such quality of heating oil distillate will probably cause consumer difficulties if such a distillate is used in poorly designed or the wrong type of domestic oil burner but I nevertheless firmly believe that this catalytically cracked material is what the refining industry is going to produce almost exclusively in the near future.

Table 4 lists the inspections of the gasoline quality as produced in our 1950 refinery.

Comparing these data with the inspections for the 1938 refinery shown in Table 2 it can be seen that the outstanding differences are that the boiling range of the 1950 gasoline is shown as being appreciably higher than in 1938; that the ASTM octane number of the regular gasoline has increased from 72 to 79 while the Research octane number has increased from 77 to 85. We have estimated that for the premium grade gasoline the ASTM octane number will have increased from 79 to 84 while the Research octane number will have increased from 84 to 94. The change in the chemical composition for the 1950 gasoline in general is a pronounced increase in the percentage of aromatic and olefinic compounds with a corresponding decrease in the percentage of paraffinic and naphthenic constituents.

Irresistible Pressure Seen

The reason we have estimated that there will be an increase in the boiling range of the 1950 gasoline is because of the inherent characteristics of catalytic cracking units to produce high-octane number quality in the heavy gasoline boiling range. For instance, a catalytically cracked naphtha boiling between 400°F. and 450°F. will have an ASTM octane number of 78 and a Research octane number of 89. This high quality in a catalytically cracked naphtha coupled with the expected high demand for gasoline will, I believe, provide an almost irresistible pressure on refineries to include this relatively heavy material into their gasoline production. This situation is already becoming evident in certain sections of the country which are currently being supplied by refineries having an appreciable amount of catalytic cracking capacity.

As has already been pointed out, the projected gasoline quality for the 1950 refinery has been predicated on the production of 25 percent of the total gasoline as the premium grade. If, in 1950, the percentage of premium gasoline demand should be as low as the 1938 figure, namely 10 percent, the octane numbers of the housebrand gasoline then would be 79.5 ASTM and 86.5 Research and the premium gasoline 85 ASTM and 95.5 Research. If, on the other hand, the demand for premium gasoline should continue into 1950 at its present percentage of 40 percent of the total gasoline demand it is estimated that the octane numbers of the housebrand gasoline would in that case be 78 ASTM and 83.5 Research with premium gasoline 83 ASTM and 93 Research.

It is perhaps coincidental that the 1950 gasoline octane numbers we have arrived at by this laborious process are very close to those numbers indicated by projecting the historical rate of increase of the anti-knock quality to 1950 but nevertheless it does seem reasonably certain that both the automotive and the petroleum refining industries may well expect this indicated quality of gasoline by 1950.

In an effort to show the effect of the changed refinery processing on the octane numbers of the gasoline in our hypothetical refinery between 1938 and 1950 Table 5 has been prepared. This table shows various base gasolines going to make up the total gasoline production in both cases, and the ASTM and Research blending octane numbers of the various components.

TABLE 5

Blended Octane Numbers

Gasoline Component	1938			1950		
	Percent	ASTM	Research	Percent	ASTM	Research
Straight Run	31.6	60	60	29.2	60	60
Reformed	18.7	65	73	17.3	65	73
Thermal cracked	36.8	68	75	8.0	65	72
Cat cracked	....	....	....	31.6	81	94
Polymer	7.7	90	105	5.3	90	105
Alkylate	....	....	....	3.2	90	94
Refinery B B	5.2	94	94	5.4	91	99
Total Gasoline (without outside butanes)	100.0	68.3	73.4	100.0	72.9	80.3

This table indicates forcefully the effect of the substitution of catalytic cracking for the major part of the thermal cracking in a modern refinery.

The ASTM octane number of the total refinery gasoline production has been increased 4.5 numbers and the Research octane number by 7 numbers. This latter increase is of particular importance because there is a growing belief on the part of our technical people that the Research octane numbers are more indicative of the road performance of gasoline than are the ASTM numbers and it is quite probable that the Research method will become controlling in future specifications.

Catalytic Cracking Essential

A study of the figures in Table 5 will show that the increased gasoline quality in the 1950 case was obtained almost solely by the substitution of catalytically cracked gasoline for the thermal-cracked product and furthermore that to obtain an equal overall quality improvement without catalytic cracking would be almost out of the question. For instance, if the total increased quality were to be obtained altogether by improving the quality of the reformed gasoline, it would require that the Research octane number of the reformed gasoline would have to be well over 100. Furthermore, any radical development in a reforming process could equally well be applied to a refinery equipped with catalytic cracking so that therefore it appears that the refinery of tomorrow will have to have catalytic cracking if it is to produce competitive quality gasolines. Catalytic cracking is not a refinement of thermal cracking but from the standpoint of producing gasoline quality it is as far ahead of thermal cracking as thermal cracking is ahead of simple distillation. Few refineries could exist in 1938 without thermal cracking facilities, and in my opinion, few refineries making average quality gasoline will be able to exist in 1950 and beyond without catalytic cracking facilities.

If this be true it is bound to intensify the already serious problems of the small refinery. Cata-

lytic cracking units are costly to build and expensive to operate and, as is almost invariably the case, the more costly the process is, the greater the penalty of building and operating small capacity units. Capital investment today for a catalytic cracking unit of a size to produce 7000 barrels of gasoline per day is about $800 per daily barrel of gasoline production and is nearly three times the cost of a thermal cracking unit of the same gasoline production capacity. For a smaller catalytic cracking unit of a size to produce 1500 barrels of gasoline per day the capital investment is about $1200 per daily barrel of gasoline production. For even smaller capacities in catalytic units the unit costs will, of course, be even greater.

Improvement in the value of yields due to catalytic cracking versus thermal cracking is just as real in small units as in larger ones but the penalty against the small catalytic units due to higher unit operating costs and particularly due to the higher unit capital charges is serious. For instance, the difference between the capital investment per daily barrel of gasoline production for the 7000-barrel catalytic unit versus the 1500-barrel unit is perhaps $400 per daily barrel of gasoline production.

If the capital charges, including maintenance expense as well as depreciation and interest, amount to 20 percent per year, the production cost of the gasoline from the small unit will be more than one-half cent per gallon higher than from the larger unit due to the higher unit capital cost of the smaller unit. This points up one of the generally unpalatable facts of economic development, to wit, that as process industries become more complex requiring more capital investment per unit volume of production, the free play of economic forces tends to concentrate such processing industries into larger and larger units. Many of the small refineries in this country today will weather the storm created by the general adoption of catalytic cracking and the attendant increase in gasoline quality by installing catalytic units of their own or in conjunction with others. Some by virtue of geography or a preferential crude supply or by concentrating on the manufacture of other products than gasoline or even through the production of a lower than average quality gasoline will successfully meet this challenge, but on the other hand many, perhaps too many, of the present small refineries will not be able to survive the gasoline quality competition that almost surely lies ahead and we may expect an acceleration in the rate of decline in the number of operating refineries in this country which number reached its peak back in 1934.

Is the octane race worthwhile? Worthwhile to whom? To the owner and operator of a small refinery faced with the problem of installing increasingly expensive process facilities and competing with the inherently less costly production from larger units or attempting to market his gasoline of less than competitive quality at less than competitive prices; his original economic advantages of transportation savings and flexibility of operations being slowly but surely whittled down by the hard cold facts of economic and technological developments. To this refinery, be it owned by a large or small oil company, the octane race has been and will be a struggle for existence and most assuredly its answer to the question would be "No."

Is it worthwhile to the owner and operator of a large refinery when competitive gasoline quality forces him to pyramid millions of dollars on millions of dollars to his capital investment and to relegate to the scrap heap refinery processes which still could have years of serviceable life? True, many of the new processes enhance the yield value of a barrel of crude oil and with steadily increasing volume of business he can justify economically the huge expenditures required but many a thoughtful refinery manager has looked back at the record of increasing gasoline quality and decreasing gasoline price and has wondered if such a race is worthwhile. The most truthful answer that could be given by such a man to our question would be a non-committal "Maybe."

Engineering Firms Say "Yes"

Is the octane race worthwhile to the engineering firms and equipment suppliers which service the refining industry? The answer is so apparent it scarcely needs a reply since the octane race has provided the bread and butter, yes and cake too, for such outfits for years. Their answer would be a unanimous "Yes."

Is it worthwhile to the automotive industry? This industry has, for years, been able to design and produce new cars having better efficiency or performance characteristics than those produced the year before. A major reason for this development has been that the petroleum industry has consistently produced and made readily available a higher quality gasoline than the currently produced cars required. This consistent improvement in the performance of the new model cars certainly played no small part in increasing the demand for the new cars. Certainly the availability of better fuels was not the only factor aiding in the design of new cars which stimulated the demand; there were many other factors both engineering and sartorial but I feel sure that the automotive industry would agree that the consistent improvement in gasoline quality has in the past and will again in the future aid them in the marketing of increasing numbers of new and better automobiles and trucks. Therefore I believe this industry would return a unanimously affirmative answer to our question.

Is the octane race worthwhile to the petroleum industry as a whole? The greatest single factor contributing to the acknowledged virility of the petroleum industry is that it has been and still is a rapidly expanding industry. The growth of our industry goes hand in glove with the growth of the automotive industry whose products consume directly about 50 percent of our entire production and indirectly create a demand for a great deal more. Our contribution to the growth of the automotive industry by producing and marketing better and better fuels thus encouraging the design and production of more and better automotive vehicles is returned to us many fold in ever increasing demand for our products. There have been and there will be economic casualties particularly in the refining branch of our industry along the road of ever increasing gasoline quality,

but the petroleum industry as a whole has profited and profited well by continually building better and better fuels for internal combustion engines.

Is the octane race worthwhile to the people of this country? Although the people are the final jury, they are not unbiased because it is they who aid and abet the octane race itself. Influenced by advertising claims perhaps they tend to place their business with the oil companies having the highest quality gasoline. It is true that often they buy gasoline too high in quality to be completely appreciated by their present car but through their buying preference they set in motion a whole train of circumstances leading to ultimately more efficient cars for themselves and a higher level of industrial production for all. It seems to me that the so-called octane race which historically has consisted of the petroleum industry selling greater and greater quantities of higher and higher quality gasoline at prices which have been well below the price level of other commodities, and which has contributed to the expansion of the automotive industry and consequently all industry, should be regarded as an outstanding example of the advantages of free enterprise in a democratic state. Looking at the broad picture it appears impossible to believe otherwise but that the octane race, heartbreaking as it seems at times, is worthwhile for our industry and the country as a whole.

Let me raise the question as to how long this continual increasing of gasoline quality will continue. Frankly I haven't the slightest idea, b[illegible] I do know of three eventualities any one of which could terminate the octane race:

1) If our research and development organizations were no longer able to invent and develop new and improved processes for the improvement of gasoline quality—a most unlikely eventuality considering the greatly increased effort being devoted to all forms of research activities.

2) If the consumption of gasoline were to cease expanding and remain static. Under these conditions there likely would be little incentive on the part of the oil companies to increase gasoline quality since the primary urge to increase quality is to thus obtain their share or more than their share of the increased business available. Without the steadily increasing demand and the concurrent reduction in unit production costs most refiners would be unwilling to underwrite refinery capital expenditures for the improvement of gasoline quality. All forecasts of future gasoline consumption made by qualified petroleum economists indicate that we may expect continuing increase in the future gasoline demand.

3) Eventually if the petroleum industry became part of a regimented economy. If this should happen some wise guy in Washington — and here I speak from personal experience—might decide that, under the guise of the national welfare, gasoline quality could go so far and no farther. I doubt that any of our generation need worry unduly about such a catastrophe happening in our time.

Short of these three remote possibilities I personally expect to see gasoline quality improve consistently for at least the next decade. I do not know the rate of increase nor physically how it is to be obtained but I am convinced that it will happen, and, if so, the substitution of intelligent planning for wishful thinking cannot help but make our future course of action more orderly, productive and, I hope, less wasteful.

Factors in Evaluating Small Refiner's Position

DAVIS READ, Universal Oil Products Company, Chicago

MR. FRAME has discussed in an interesting manner the tremendous effect of the war-developed refining processes, particularly catalytic cracking, on the gasoline quality picture. The position of the large refiner, processing 75,000 barrels of crude per day, has been or is being rapidly secured by installation of large catalytic cracking units. The position of the small refiner without catalytic cracking in a future octane race is somewhat less secure at present for reasons mentioned by Mr. Frame. Here are several additional factors to be considered in evaluating the position of the smaller refiner.

During the war considerable experience was gained in the design and operation of six catalytic cracking units having gas oil charge capacities of 5000 barrels per day or less. Included in these was one 2600-barrel unit which now produces about 1200 barrels per day of motor gasoline. Of these six units, one was originally purchased by the refiner, three have been purchased from War Assets

TABLE 1

Fluid Catalytic Cracking 23° API Heavy California Gasoil Commercial Results

Yields, Volume Percent of Charge:

Dry gas, cubic feet/bbl., charge	382
Propane-propylene cut	4.4
Butane-butylene cut	7.1
Light gasoline	17.2
Heavy gasoline	16.5
Light cycle oil	23.2
Heavy cycle oil	27.5

Properties of Charge and Products:

	Charge Stock	Light Gasoline	Heavy Gasoline	Light Cycle Oil	Heavy Cycle Oil
Gravity, °API	23.0	67.3	38.9	23.3	19.4
Aniline point, °F	160	.....	.....	100	150
Percent Sulfur	0.80	0.07	0.19	0.70	0.60
Flash point, °F	260	.....	.....	240	220
Conradson carbon, wt. percent	0.12	.....	.....	0.03	0.94
Octane Numbers,					
Motor method clear	.....	79.2	79.6	.....	.....
Research method clear	.....	94.7	93.3	.....	.....
100 Ml Distillation:					
IBP, °F	390	107	269	451	.....
10 percent	600	128	286	492	.....
50 percent	740	162	327	542	.....
90 percent	860	220	389	622	.....
End point, °F	.....	259	438	679	.....

Administration since V-J day, and the purchase of the remaining two units is being negotiated. Four of these units are in successful operation producing motor gasoline and distillate fuels economically. In addition, since V-J day, seven smaller refiners each has decided to install a new catalytic cracking unit having a charge capacity of 5000 barrels per day or less. One of these units is in operation, and the construction of another unit is nearly completed. It would, therefore, appear that some progress is being made by the smaller refiner in modernizing his operations to meet competition.

While it is true that the installation and operating costs for catalytic cracking are somewhat greater than for thermal cracking, the data being obtained from small catalytic cracking units show that with the present price structure and octane requirements their operation can be justified over thermal cracking on the basis of their ability to produce higher yields of gasoline and distillate fuels with lower tetraethyl lead and treating costs. These advantages of catalytic cracking will, of course, accrue to both large and small refiners, but it should be emphasized that a small refiner without catalytic cracking will be competing with larger refiners not only on the basis of future high gasoline quality but also on the basis of actual yields of gasoline and distillate fuel per barrel of crude processed.

In this connection Table 1 has been prepared to show the results being obtained commercially in fluid catalytic cracking a 23°API-gravity heavy California gas oil. The unit was operated at a conversion of approximately 50 per cent in order to produce relatively low boiling distillate fuel as well as high octane motor gasoline from the vacuum gas oil. Note that the light catalytic cycle stock produced represents 23.2 per cent of the charge and has a 50 per cent point of 542°F as compared with a 50 per cent point of 740°F on the fresh feed. It is also interesting to note that the light and heavy gasolines produced in this operation have sensitivities (Research method-Motor method octane) of 14 to 16 unleaded.

Our experience has shown that the present cost of a simplified small fluid catalytic cracking unit is more nearly comparable with the cost of a thermal cracking unit of the same gasoline producing capacity than Mr. Frame has indicated. The estimated installation and operating costs for thermal cracking and fluid catalytic cracking are compared in Table 2. The comparison is based on installing all new equipment in each case to process 3500 BSD (barrels per stream day) of Mid-continent reduced crude which might be available from 7000 BSD of crude oil. The thermal cracking unit would process the entire reduced crude at an installation cost of about $500 per barrel of gasoline produced and at an operating cost of 25 cents per barrel of charge. The reduced crude would be vacuum flashed at an operating cost of 7 cents per barrel of feed in the catalytic cracking scheme to produce 2870 BSD of gas oil which would be cracked at a cost of 35 cents per barrel of feed. The total installation cost for fluid catalytic cracking including feed preparation, would be about $700 per barrel of gasoline produced, or only 1.4 times the corresponding installation cost for thermal cracking.

TABLE 2

Comparison of Estimated Installation and Operating Costs

	Thermal Cracking	Fluid Catalytic Cracking
Installation Costs:		
3,500 BSD Thermal Cracking	$ 900,000	.....
3,500 BSD Vacuum Distillation	.....	$ 150,000
2,870 BSD Fluid Catalytic Cracking	.....	1,100,000
Total	900,000	1,250,000
Dollars/Barrel of Gasoline Produced	500	700
Direct Operating Costs, Cents/Barrel of Feed:		
3,500 BSD Thermal Cracking	25	.....
3,500 BSD Vacuum Distillation	.....	7
2,870 BSD Fluid Catalytic Cracking	.....	35

In spite of these higher installation and direct operating costs it is estimated that the catalytic cracking scheme will produce gasoline for 0.3 cents per gallon less than the thermal cracking scheme, due to greater yields of valuable products and savings in tetraethyl lead and treating costs.

Small Refiner's Chance of Staying in Business

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MR. FRAME'S paper was extremely interesting and, in view of the current economic conditions, very timely. As a matter of fact, as a representative of a company that has an exceedingly vigorous affirmative answer to his main question—and I must admit that we are in the business of making our bread and butter and sometimes cake—perhaps I should refrain entirely from commenting on the paper. However, there are several points on which we do not agree entirely and, in order to be brief, I have limited my discussion to two: namely, 1) how can the octane numbers of 1950 be achieved, and 2) what solace is there for the independent refiner?

Mr. Frame forecasts regular gasoline octane numbers ranging from 77 to 79.5 ASTM and from 85 to 86.5 Research, and premium gasoline octane numbers ranging from 83 to 85 ASTM and from 93 to 95 Research. During the past few years, the Houdry Company has made many economic studies of the application of Thermofor catalytic cracking to refining operations, both large and small. Our comments on this aspect of Mr. Frame's paper can, therefore, be quite brief: To produce gasoline with

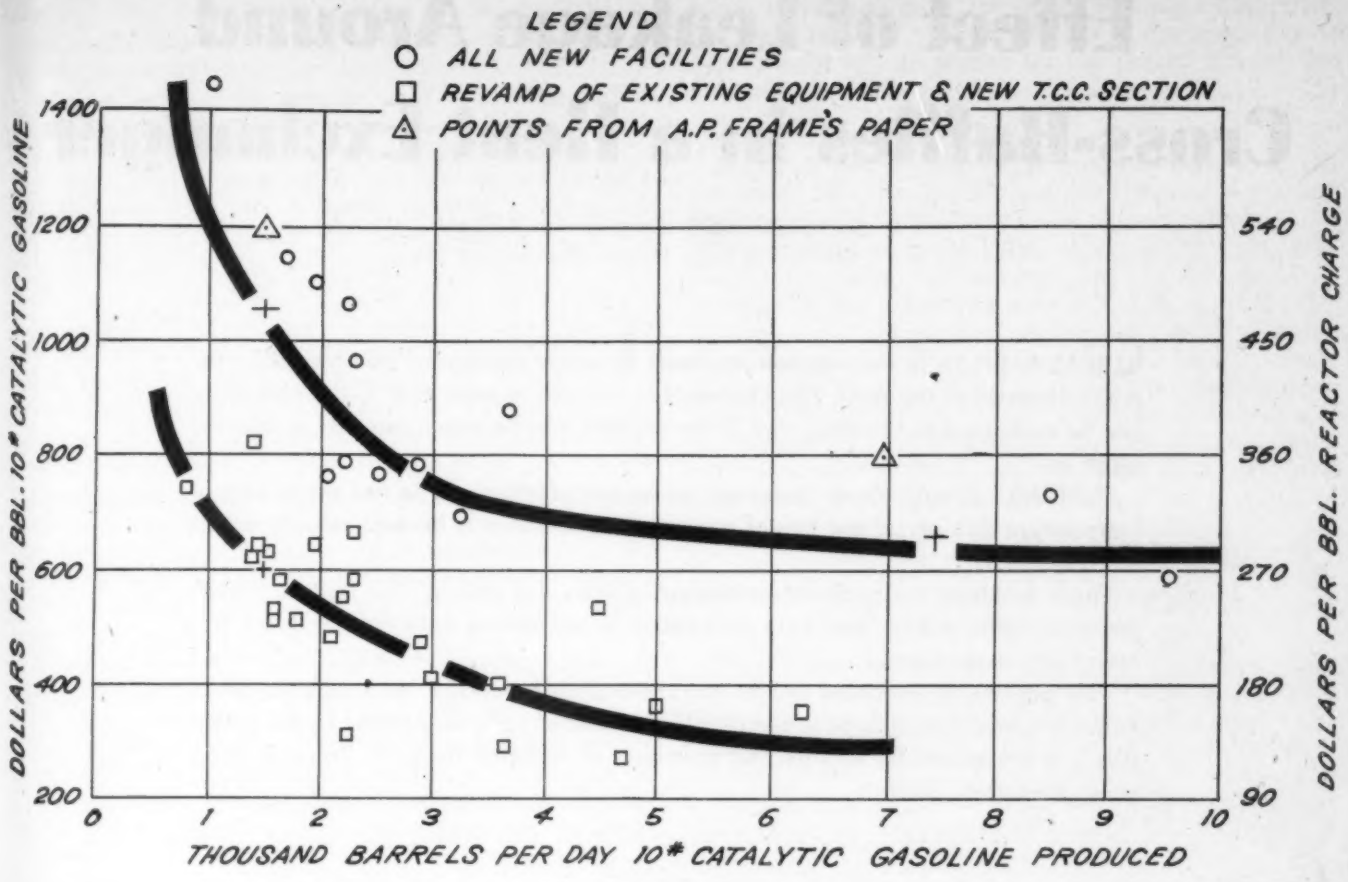

FIGURE 1

octane numbers in the range predicted, catalytic cracking becomes a "must." We concur in Mr. Frame's conclusion that the refinery of tomorrow will have to have catalytic cracking in order to produce competitive quality gasoline.

As to the second question, Mr. Frame paints a dreary picture for the independent refiner and suggests that he must have a marketing advantage of ½ cent a gallon in order to remain competitive. This figure is based upon an assumed differential of approximately $400 investment per daily barrel of gasoline production.

There are a great many factors other than size of plant which determine the cost of a barrel of catalytic gasoline. Among these are utilization of existing equipment, processes operated in conjunction with catalytic equipment, mechanical specifications, choice of contractors, etc.

When a plant is designed to produce 7000 to 8000 barrels per day of catalytic gasoline, it becomes necessary in almost every case to engage in long and expensive design studies and to "tailor make" the new equipment to fit the needs contemplated for the future. In the case of the independent refiner, however, where the problems are duplicated nearly everywhere, it is possible to establish and standardize upon design so that the problem is not one of building complete new process equipment but one of installing a catalytic cracking section that has already been completely engineered and of fitting existing pieces of equipment to it. This, of course, reduces to a minimum the engineering and installation costs.

To illustrate the variation in investment as a result of one or more of the above factors, we have selected at random, economic studies of TCC cracking developed for 40 different refineries. Of these, five charged less than 5000 barrels per day of crude oil, 20 charged between 5000 and 8000, eight charged between 8000 and 20,000 and seven charged more than 20,000 barrels per day. Investments, including all process facilities, were determined for each case as dollars per daily barrel of catalytic gasoline produced. No attempt was made to correct to a common basis, since each point represented a practical application of catalytic cracking to that refinery.

The graph (Figure 1) shows that they fall into two lines. The upper line, designated by the circles, is the investment cost per daily barrel of catalytic gasoline to be produced correlated against thousands of barrels of gasoline a day to be produced where completely new facilities are to be installed. The circles are slightly scattered, but nevertheless show a regular trend. Now, the lower curve presents a similar relationship where existing auxiliary equipment and facilities are to be utilized with TCC equipment. It is significant that the independent refiner desiring 1500 barrels per day of catalytic gasoline can, by conversion of thermal cracking units and careful attention to the other factors mentioned, build a plant at an investment per barrel comparable to that required for a large refiner to produce 7000 barrels per day of catalytic gasoline from all new equipment.

It so happens that the investment cost of one small TCC unit which has been built in conjunction with existing facilities fits this curve very well and, therefore, is the correct answer to Mr. Frame that the smaller refiner does have a very satisfactory way of competing with the big refiner and staying in business.

Effect of Leakage Around Cross-Baffles in a Heat Exchanger

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CROSS-BAFFLES in heat-exchangers must be made smaller in diameter than the inside diameter of the shell. This clearance is provided in order that 1) the exchanger can be assembled in the shop, and 2) the element can be withdrawn and re-inserted after use.

Fluid leaks through these clearances cause loss of efficiency in two ways: Loss of temperature difference, and loss of heat-transfer rate due to lowered velocity across the tube-nest.

These problems are analyzed mathematically by the author. The results, though based on mathematics, may have application in correlating data from tests on different size exchangers.

This paper was presented at the Petroleum Division of the 1947 Conference on Petroleum Mechanical Engineering (ASME) in Houston early in October by the author who is a consultant for process and supervisor of research for C. F. Braun & Company, Alhambra, Calif.

CONDITIONS assumed in the derivation are set forth below. Also, several approximations are made, which will be described later.

(1) True counter-current, or true parallel-flow, throughout. Figure 1 is for counter-current.

(2) No heat loss to the air. No heat conduction through the baffles. No leakage around the tube-holes through the baffles.

(3) Rate of flow, specific heats, heat transfer rates, phase conditions—all remain constant through the exchanger.

(4) Complete mixing of leakage and main flow as they pass through the cuts in the baffles.

Explanation of Flow

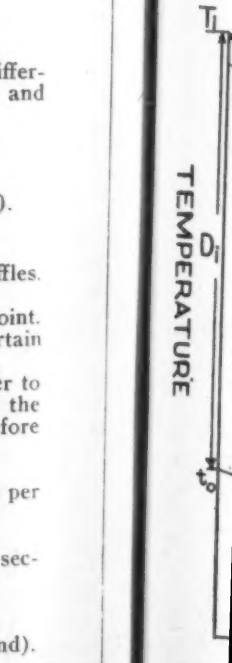
The upper picture in Figure 1 represents the flow and construction in the shell-side of the exchanger under consideration. It has so called crossflow baffles which have segmental openings. These baffles force the fluid to flow at right angles to the tubes. Entering flow W passes through Section 1, then at right angles

NOMENCLATURE

a Fraction of crossflow that leaks around each cross-baffle.
A_1 Area of leakage past each baffle (square inches). For this paper assumed equal 120 degrees of arc times clearance.
A_c Net area of crossflow per baffle section (square inches).
b Baffle clearance on diameter (inches).
B An expression as defined in equation (2_d).
C Specific heat of fluid in shell.
d I.D. of exchanger shell (inches).
D Difference in temperature between fluid inshell at any point (degrees F.).
D_i Difference in temperature between fluids at inlet of shell (degrees F.).
D_o Same for outlet.
D_n, D_{n-1} Same for various points in the shell as shown by Figure 1.
F Correction factor used to obtain true mean temperature difference.

$$F = \frac{\text{Corrected MTD}}{\text{Log MTD}}$$

G The expression $a\,\frac{(T_i - T_o)}{\text{Log MTD}}$
K Velocity heads used up by shell-fluid in flow through two crossflows and one baffle.
Log MTD Logarithmic Mean Temperature Difference for whole exchanger using inlet and outlet temperatures.
MTD Mean Temperature Difference.
n Crossflow section number. (See Figure 1.)
N Total number of crossflow sections.
p Density of shell-fluid (pounds per cubic foot).
R $\frac{D_i}{D_o}$
S Total surface of exchanger having leaking baffles.
S_t Total surface of a perfect exchanger.
t Temperature of the fluid in tubes at any point. Subscripts refer to various values at certain sections.
T Temperatures of fluid inshell. Subscripts refer to values at certain sections. T' refers to the fluid as it leaves the nest of tubes just before mixing with the leakage.
u Velocity through leakage (feet per second).
U_a Inshell heat transfer rate with leakage (Btu per hour per °F. per square foot).
U_o Same for zero leakage.
V_a Crossflow velocity with leakage (feet per second).
V_o Same for zero leakage.
W Total flow inshell (pounds per second).
X Crossflow between baffles (pounds per second).



through the segmental opening in the first baffle, then back through Section 2, and so on through the whole exchanger.

The element is removable, and hence the baffles must be made smaller than the shell. This clearance allows leakage ax around the baffles. Except in the first and last sections, this leakage occurs on both sides of the shell, as shown in Section n—1, n, and n + 1. Flow through the tube nest is X, while total flow

$$W = X + ax + ax$$

Now for an analysis of a typical Section n. The lower picture of Figure 1 shows the various temperatures involved. Flow of quantity, X, starts down across the tube nest with temperature T_n—1. This temperature is the result of mixing leakage ax from Section n-2, and crossflow from Section n-1.

Temperature of flow, X, drops as it crosses the tube nest finally emerging as T_n^1. It mixes with leakage ax from Section n-1, rising in temperature to T_n. This alternate leakage through the exchanger results in the sawtooth temperature gradient of the lower picture.

Leakage does not enter the first section at all. Nor does leakage enter Section 2 until the flow leaves the tube nest. This means that the temperature gradient for first two sections follows the dotted line which forms the lower boundaries of the shaded area in these sections. But for the sake of avoiding impractical complexity, our mathematics assumes the sawtooth construction of the other sections. The outlet section has a very slightly different gradient, due to higher velocity, as shown by the dotted line in this section.

Derivation

An exact solution to this problem appears to be impractical. We are therefore forced to use a method that logic tells us is a very close approximation.

The shell-temperature line of Figure 1, marked T, actually represents to different, but almost coinciding lines. Both lines actually pass through point T_i and T_o. But in the center they undoubtedly differ slightly. One line joins the tops of the sawteeth for the actual exchanger. The other line represents the temperature curve for a perfect exchanger. Only one line is shown. The assumption is made that the two lines coincide. An indication of the accuracy of this approximation is given in the following reasoning.

It can be shown that in a perfect exchanger

$$\text{Log } D_n = \left(\frac{N-n}{N} \quad \text{Log } \frac{D_i}{D_o}\right) + \text{Log } D_o \qquad (1)$$

This means that D_n can be plotted on semilog paper, against n as a straight line. This is the solid line of Figure 2. A similar line can be drawn for the actual exchanger. This is the dashed line of Figure 1, shown crossing through the sawteeth. It is also the dashed line of Figure 2. This line is so located that when used in the standard Log MTD Formula it

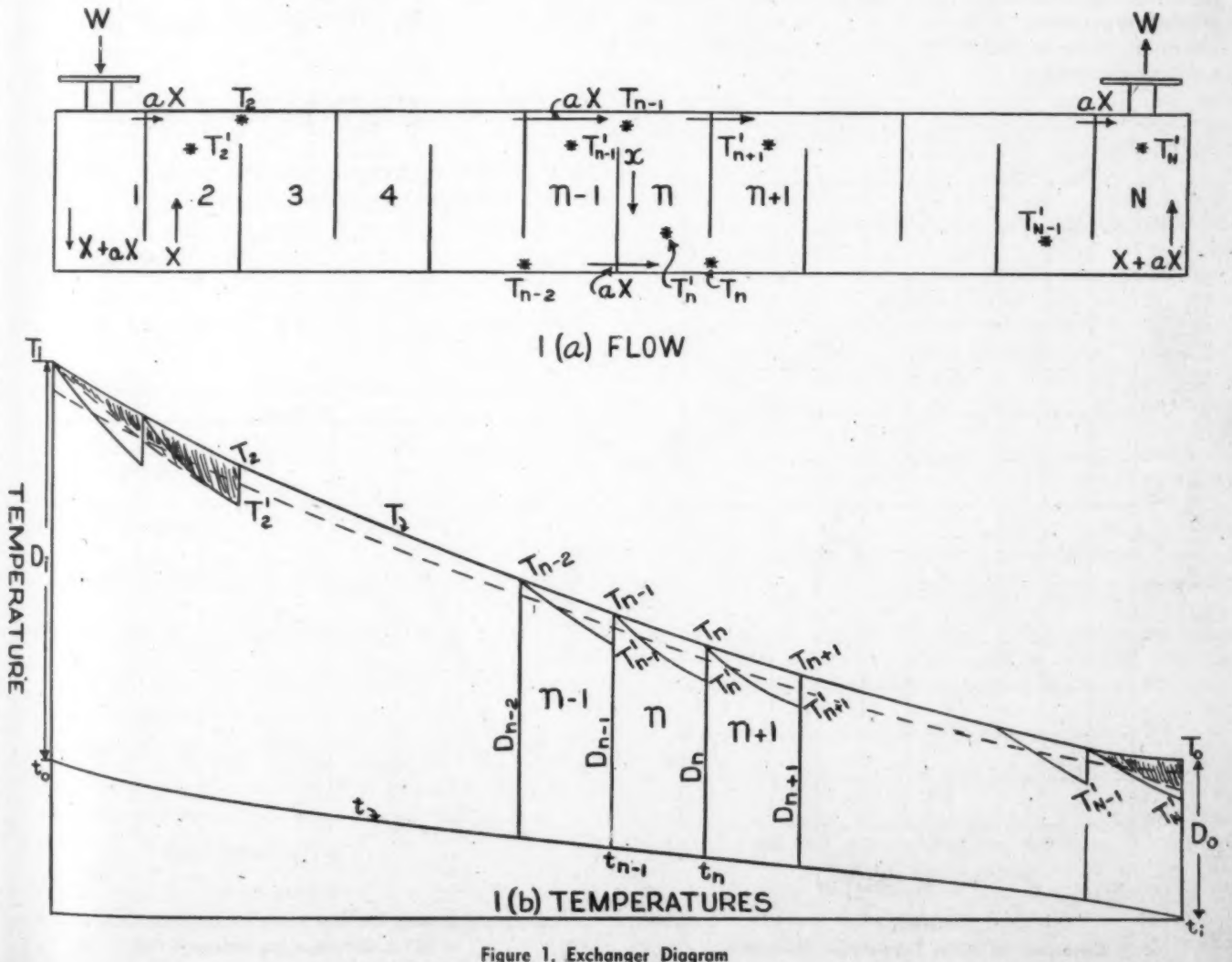


Figure 1. Exchanger Diagram

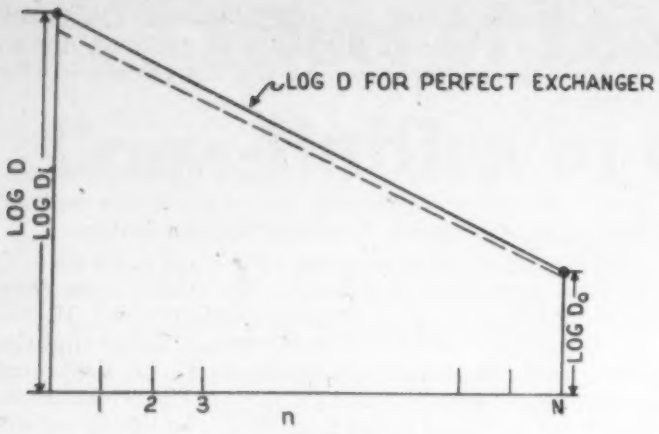


FIGURE 2
Log Temperature Difference vs. Baffle Position

gives the corrected MTD for the actual exchanger.

It has to pass through the sawteeth near their centers. It also is a straight line on Figure 2. For it also follows equation (1), since equation (1) is merely another form of the Log MTD formula. The logarithmic differences between the two lines is set by their differences at the ends of the exchanger. Therefore, since the solid line starts and ends at the tops of the sawteeth, it will be very close to coincidence with them over the rest of the exchanger.

There are two ways in which baffle leakage causes loss of efficiency. One is by loss of temperature difference. The exchanger must transfer heat with a lowered temperature difference than in a perfect exchanger. This is shown by the sawtooth lines of the actual exchanger.

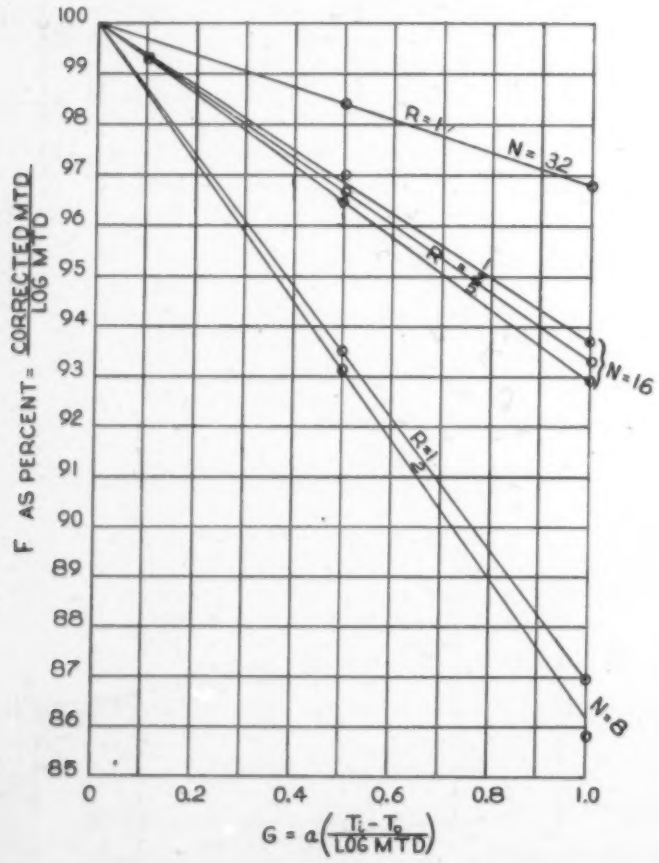


FIGURE 3
Correction for Mean Temperature Difference

The other loss of efficiency is due to lowered velocity. The actual flow through section n is x. With no leakage the flow would be W. This lowered velocity results in a lower heat transfer rate.

The first loss is expressed as F, a correction factor for Log MTD. The second loss is given by $\frac{U_a}{U_o}$. We will derive F first.

$$\text{MTD for Section } n = \frac{T_{n-1} - t_{n-1} - T_n' + t_n}{LOG_e \frac{T_{n-1} - t_{n-1}}{T_n - t_n}} \qquad (2)$$

$$\text{By heat balance } T_n' = T_n - a(T_{n-2} - T_n) \qquad (3)$$

Substituting (3) into (2), inverting the denominator, and inserting the various values of D

$$\text{MTD for Section } n = \frac{D_n\left[1 - \frac{D_{n-1}}{D_n} - a\left(\frac{T_{n-2} - T_n}{D_n}\right)\right]}{LOG \frac{D_n}{D_{n-1}}\left[1 - a\left(\frac{T_{n-2} - T_n}{D_n}\right)\right]} \qquad (2a)$$

From equation (1), and substituting R for D_i/D_o we get $\frac{D_{n-1}}{D_n} = R^{1/N}$ (4)

$$\text{MTD for Section } n = D_n\left[\frac{1 - a\left(\frac{T_{n-2} - T_n}{D_n}\right) - R^{1/N}}{LOG_e\left\{1 - a\left(\frac{T_{n-2} - T_n}{D_n}\right)\right\} - LOG_e R^{1/N}}\right] \qquad (2b)$$

The expression $\left(\frac{T_{n-2} - T_n}{D_n}\right)$ can be changed as follows:

In a perfect exchanger, without leakage, the MTD for the combined sections n-1 and n is

$$\frac{D_{n-2} - D_n}{LOG_e \frac{D_{n-2}}{D_n}} \qquad (5)$$

By using equation (1) and substituting R we get

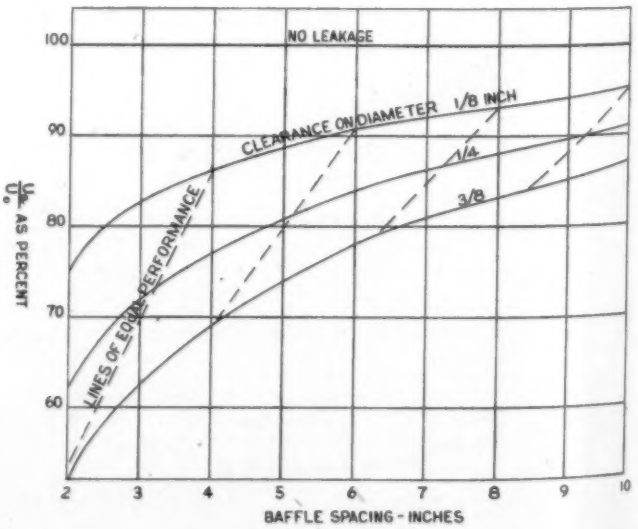


FIGURE 4
Comparison of Heat Transfer Rates for Different Clearances in in 24 i.d. Exchange. No leakage = 100.

$$\frac{D_{n-2} - D_n}{LOG_c \frac{D_{n-2}}{D_n}} = D_n \left(\frac{R^{2/N} - 1}{LOG_e R^{2/N}} \right) \quad (5a)$$

Equating surface equal to Heat/MTD/U, and rearranging we get

$$\frac{T_{n-2} - T_n}{D_n} = \frac{2}{N} \left(\frac{T_i - T_o}{LOG\ MTD} \right) \left(\frac{R^{2/N} - 1}{LOG_e R^{2/N}} \right) \quad (6)$$

But

$$\frac{S_i U}{WC} = \frac{T_i - T_o}{LOG\ MTD}$$

So,

$$\frac{T_{n-2} - T_n}{D_n} = \frac{2S_i}{N} \frac{U}{WC} \left(\frac{R^{2/N} - 1}{LOG_e R^{2/N}} \right) \quad (7)$$

Substituting (7) in (2b)

MTD for Section

$$n = D_n \left[\frac{1 - \frac{2a}{N} \left(\frac{T_i - T_o}{LOG\ MTD} \right) \left(\frac{R^{2/N} - 1}{LOG_e R^{2/N}} \right) - R^{1/N}}{LOG_e \left\{ 1 - \frac{2a}{N} \left(\frac{T_i - T_o}{LOG\ MTD} \right) \left(\frac{R^{2/N} - 1}{LOG_e R^{2/N}} \right) \right\} - LOG_e R^{1/N}} \right] \quad (2c)$$

For simplicity let B equal the expression in the brackets.

MTD for Section $n = D_n B$ (2d)

Using equation (1) again we find

$$D_n = D_o R^{\frac{N-n}{N}} = D_o R R^{-n/N} \quad (8)$$

Substituting (8) into (2d)

MTD for Section $n = D_o R B R^{-n/N}$ (2e)

The same process is applied to the other sections

MTD for Section $1 = D_o R B R^{-1/N}$ (2f)

MTD for Section $2 = D_o R B R^{-2/N}$ (2g)

MTD for Section $3 = D_o R B R^{-3/N}$ (2h)

MTD for Section $N = D_o R B R^{-1}$ (2j)

The heat transferred in any section of the actual exchanger is

$$\frac{S}{N} U D_o R B R^{-n/N}$$

The heat transferred in the whole exchanger is

$$SU(\text{Corrected MTD}) = \frac{S}{N} U D_o R B (R^{-1/N} + R^{-2/N} \ldots\ldots + R^{-1}) \quad (9)$$

$$\text{Corrected MTD} = \frac{D_o R B}{N} (R^{-1/N} + R^{-2/N} \ldots\ldots + R^{-1}) \quad (9a)$$

To find F, we divide by Log MTD. But

$$LOG\ MTD = \frac{D_o (R-1)}{LOG_e R} \quad (10)$$

$$F = \left(\frac{B}{N} \right) \left(\frac{R}{R-1} \right) (LOG_e R) (R^{-1/N} + R^{-2/N} + R^{-3/N} \ldots\ldots + R^{-1}) \quad (11)$$

Values for F are plotted on Figue 3. Each value of N has a family of closely grouped curves, each curve having a particular value of R. By proper spacing of the values of N, the curves do not overlap. For practical purposes the curves are straight lines in the range considered.

To use this chart we need to know the value of a, the leakage. This is developed in our derivation for the lowered heat transfer rate due to lowered velocity.

For simplicity assume that the leakage is measured by 120 degrees of arc on the baffles.

$$A_l = d\pi \frac{120}{360} \frac{b}{2} = 0.5\, db$$

$$V_o = \frac{W}{P} \frac{144}{A_c}$$

$$V_a = \frac{X}{P} \frac{144}{A_c} \quad (12)$$

$$X = \frac{W}{1+2a}$$

$$\frac{V_a}{V_o} = \frac{1}{1+2a}$$

Assume that heat transfer rate varies as the 0.7 power of the velocity.

$$\frac{U_a}{U_o} = \left(\frac{1}{1+2a} \right)^{0.7} \quad (13)$$

Assume that one velocity head is used by the leaking stream. Pressure drop available is equal to the pressure drop of the main stream flowing through one baffle segment and two crossflows.

$$\frac{KV_a}{64} = \frac{u^2}{64}$$

$$\frac{u}{V_a} = \sqrt{K}$$

$$\text{up } \frac{A_l}{144} = aX$$

$$V_a p \frac{A_c}{144} = X \quad (14)$$

$$\frac{u}{V_a} = a \frac{A_c}{A_l}$$

$$a = \frac{A_l}{A_c} \sqrt{K}$$

Figure 4 shows the effect of baffle clearance for a 24-inch i.d. exchanger. No other sizes are given since the curves would overlap. Curves for the larger sizes in general move horizontally to the right.

This chart may not be required for normal exchanger problems when the baffle spacing falls near the spacing used in tests made to establish heat transfer curves. But it is easy to see that selection for close spacings ought to be corrected.

The dashed lines of Figure 4 show baffle spacing required with different clearances to give equal performance. For example a baffle spacing of 8½ inches with ⅜-inch clearance, will give the same performance as 10-inch spacing with ⅛-inch clearance. It was assumed that heat transfer varies as the 0.7 power of the actual velocity when making these lines.

Figure 5 shows gain in heat transfer rate when spacing baffles are closer. Basis is 100 for 10-inch spacing with no leakage. Occasionally low flow-rates inshell need close spacing to maintain a reasonable heat transfer rate. Arbitrary rules have set minimum spacing.

The curves show that for this exchanger heat transfer rates are increasing even at two inch spacing. In larger exchangers, the transfer rates may reach a maximum at this point. It appears that spacings can be used much closer than the rules have allowed, provided that cleaning is still practicable and provided that the proper corrections are made.

Construction

There are several ways of obtaining accuracy in fitting baffles to the shell. One way is to provide a thicker shell and then bore it out. This is the most accurate method, provided that the force of the cutting tool is applied longitudinally and not on the diameter. The big objection is the uncertainty of the metal thickness that remains.

A second method is to calibrate the shell after it is

built. This is usually done by trying progressively smaller discs until one goes through easily. Then the baffles are cut to this diameter. This method has two faults. It ruins interchangeability of elements. And, while it obtains a close fit on one diameter it leaves larger clearances on another.

A third method is to build both the shell and element. Then grind down the baffles where they hit. This has the same faults as the foregoing method.

The fourth method is a sort of combination. It recognizes the limitations of welding in the shop. And it maintains interchangeability of elements. The baffles are made accurately to size. This is easy since they are turned on a machine. The shell is either rolled and welded, or it is purchased as pipe.

If the shell is pipe, the tolerances are fairly well known. If the shell is rolled and welded, allowance must be made for shrinkage due to the weld. The nozzles must be welded on in such a way that the shell is not deformed. If welded directly to the shell, the welding around a nozzle causes the shell to buckle in, as shown in the upper part of Figure 6.

The amount of buckling depends upon the relative diameter of the nozzle and the shell, and upon the relative thicknesses of the plate and nozzle parts. The shrinkage is sometimes as much as a quarter of an inch. The construction shown in the lower part of Figure 6 consists of an annular shell into which the nozzle is welded. The shrinkage thus is kept from the inner shell. The shrinkage in roundabout welds in the shell is almost all longitudinal with the shell. Very little occurs on the diameter. This is especially true with machine welding. Flow is introduced closer to the tubesheet, and the inner shell serves as an impingement baffle.

After the shell is fabricated, it should be tested to be sure that a standard element can be drawn through it. Welding burrs and the like should be ground off. If the shell is out of round it should be brought to roundness by rerolling or by spider-jacks.

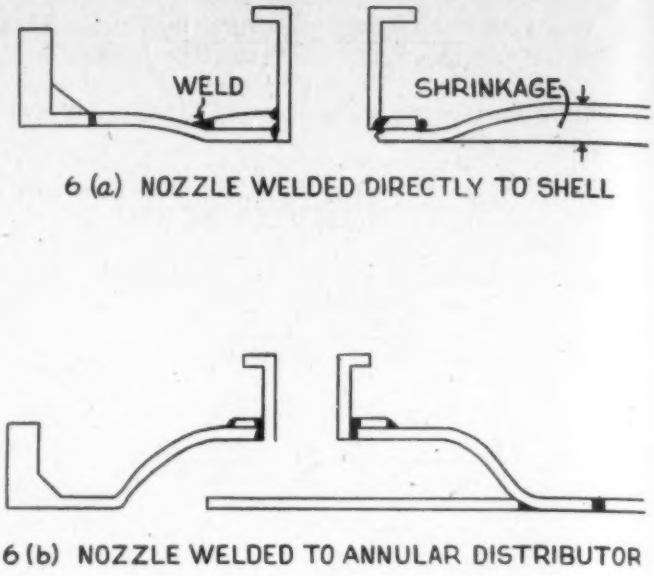


FIGURE 6
Methods of Attaching Nozzles

Often, designers of heat exchangers specify tolerances that are impracticable in the shop. The result is that the shop uses one of the first three methods to get the element in. Usually the baffles are ground down in the high spots. The designer would better consult the manufacturer as to the practicability of his design. It is better all around to allow for a nominal leakage, than to get an element that makes trouble in maintenance.

Conclusions

Leakage around the baffles of a crossflow exchanger causes loss of efficiency from two sources. First, a loss of temperature difference. Second, a loss of heat transfer rate. Formulas are derived as yardsticks to measure both these losses.

The loss in temperature difference is less than five percent for the majority of cases. Close approaches in temperature, wide temperature range in shell, and few baffles, tend to increase the loss. A combination can easily require a correction in MTD.

The correction for loss in heat transfer rate is comparatively larger. It is worth due regard in engineering. The correction depends upon clearance and baffle spacing. Close spacings require greater correction. Close spacings can be used to advantage provided that allowance is made for decreased efficiency and provided that cleaning is still possible.

Baffle clearance used must be a compromise between 1) efficiency, 2) practical manufacture and 3) maintenance. Specification of impracticable clearance is bound to result in either 4) high cost or 5) handfitting that actually results in more clearance than planned.

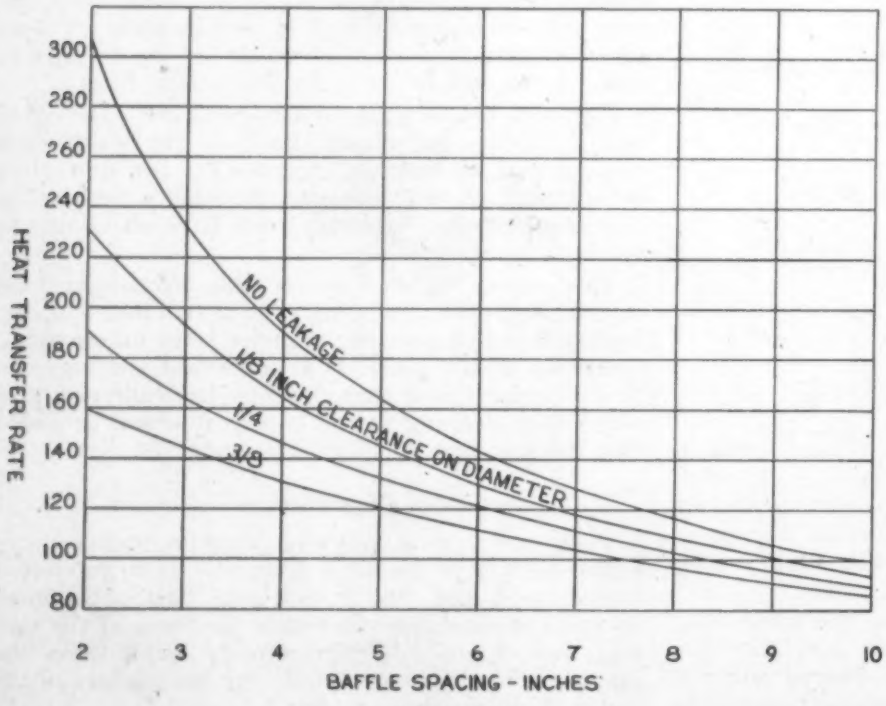


FIGURE 5
Shell-Side Heat Transfer Rate Based on 10-Inch Baffle Spacing. With No Leakage = 100

Service Life of Austenitic Alloy Furnace Tubes

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SELDOM are data available on long time service life of alloy materials available as the basis for selecting materials; hence service life data on 18-8 chrome nickel steel tubes in 1000-pound thermal cracking units for 16 years should be interesting. The tubes are 4½-inch o.d. x .400-inch wall tubes in the radiant section of furnaces having a normal coil inlet of 900-1000 psig, 1500 psig maximum, and a coil outlet of 900-100 F. with a maximum tube metal temperature of 1200° F. After five years of operation it was decided to remove a portion of the tubes each turn-around for sandblasting, inspection and reconditioning. Gradually the number removed was increased until each tube was removed after six months service. After finding cracks in some of the tubes, each tube was removed every three months. (Now tubes are removed every four months.) After most of the tubes had 60,000 service hours it was decided that tubes should be retired from service after 60,000 service hours. This decision was based on the increased rate of bulging after 50,000 hours and the roughened appearance and surface cracks and defects after 60,000 hours. The careful and frequent inspections of the tubes and the strict adherence to the 1200° F. tube metal temperature limit has held the number of failures in service to two tubes in 16 years of operation.

The paper was read at the Conference on Petroleum Mechanical Engineering of the American Society of Mechanical Engineers, Houston, October, 1947.

QUITE often it is necessary for refiners to select alloy materials based on laboratory test results or limited actual service results. Seldom are data available on long time service results. For this reason, the data on the service life of 18-8 chrome nickel steel tubes in the radiant section of the furnaces of the 1000-pound thermal cracking units at the Baton Rouge refinery of the Louisiana Division of Standard Oil Company of New Jersey should be of interest, since these data cover an operating period of 16 years.

These radiant tubes are 4.500-inches o.d. x 0.400-inch minimum wall 18-8 chrome nickel steel tubes with upset and machined ends. At first the ends were machined for a ring-type joint return bend and later for a ball type joint return bend. The furnaces operate with normal coil inlet pressures of approximately 900-1000 psig and normal coil outlet temperatures of approximately 900-1000° F. Of course, these conditions have varied from time to time depending upon the type of operations being carried out on the units; however, the maximum coil inlet pressure is 1500 psig limited by a safety valve, and the maximum tube metal temperature allowed is 1200° F.

Almost from the beginning of operations in 1931, these tubes were inspected carefully, chiefly to prevent a failure in service. Later it was felt to be desirable to keep accurate records on each tube; therefore, a card record was set up for each tube using the heat number and tube number, which are stenciled at each end of the tube, for identification. After about five years of operation, a policy was established whereby 20 tubes were removed each turn-around, sandblasted externally, inspected and straightened, if necessary, and the ends reconditioned, if necessary. As additional spare tubes were made available, the number of tubes removed each turn-around was increased to the extent that each tube would be removed and

TABLE 1
Tube Rejection Summary

Service Hours	Gun Cut	Bulged	Dented	Cracked	Over Age	Inferior Quality	Failed in Service	Transferred
0–10,000	3	0	0	0	....	....	0	....
10–15,000	0	0	1	0	....	....	0	....
15–20,000	1	0	1	0	....	....	0	....
20–25,000	5	0	0	1	....	....	0	....
25–30,000	1	2	0	0	....	....	0	....
30–35,000	3	3	1	1	....	2	0	....
35–40,000	2	5	1	0	....	7	0	....
40–45,000	7	14	2	3	....	16	0	....
45–50,000	3	22	5	2	....	1	1	....
50–52,000	1	10	2	1	....	....	0	....
52–54,000	1	5	1	0	....	....	0	....
54–56,000	3	6	2	1	....	....	1	4
56–58,000	1	2	2	3	....	....	0	16
58–60,000	0	2	1	3	....	....	0	1
60–62,000	....	1	0	3	59	....	0	....
62–64,000	....	2	0	0	48	....	0	....
64–66,000	....	4	2	2	29	....	0	....
66–68,000	....	2	0	0	34	....	0	....
68–70,000	....	2	0	1	30	....	0	....
70–72,000	....	0	0	0	13	....	0	....
72–74,000	....	0	0	0	6	....	0	....
74–76,000	....	0	0	0	1	....	0	....
76–78,000	....	0	0	0	0	....	0	....
78–80,000	....	0	0	0	1	....	0	....
Total	31	82	21	21	221	26	2	21

Note: Service hours is total time tube is installed in furnace without credit for unit downtime while the tube is in the furnace.

reconditioned at least once a year. As still more spare tubes were made available, all tubes were removed, inspected, and reconditioned twice a year.

In 1937, a tube with 31,674 service hours was found to contain cracks. At this time, the possibility of 18-8 chrome nickel steel tubes having a definite length of life was advanced; however, since there are so many variables which would affect the service life, the theory was not pushed. However, as a result of finding the cracks, it was decided to remove all tubes every three months for inspection and reconditioning.

In 1938, two more tubes were found to contain cracks. One tube had been in service 41,856 hours; the other had been in service 43,296 hours. Since all three tubes had been furnished on the same purchase order, it was felt that the material was of inferior quality and all other tubes furnished on the order were removed from service and made available for use in piping.

By the end of 1939, there were 125 tubes with more than 60,000 service hours. From the data accumulated on the periodic inspections of these tubes, it was found that when a tube had been in service about 50,000 hours, the rate of increase in diameter, or bulging, increased. After about 60,000 hours, the outside surface of the tube becomes roughened and surface defects and cracks become apparent. Since experience had shown that the tubes would be kept in service for 60,000 hours without failure and because of the acceleration of creep and the appearance of surface defects and cracks at about 60,000 service hours it was decided that tubes should be permanently removed from service after 60,000 service hours. Another reason for this limit was the fact that after 60,000 hours, the out-of-roundness and bulging was likely to become so bad that the discarded tubes could not be used for piping and would have to be disposed of as junk.

In 1943, forty-six tubes were rejected due to circumferential cracks immediately behind the upset ends. Of these tubes, 23 had about 50,000 service hours, two had about 24,000 service hours. Investigation of these tubes by the manufacturer showed that the cracks were caused by mechanical stresses due to the design of the tube ends and return bends. The tube ends were changed slightly to reduce the possibility of such cracks and new tube ends were obtained and welded to the tubes. Those which had cracked after 50,000 service hours were satisfactory for 55,000 to 60,000 service hours. The others were satisfactory for about 50,000 service hours. This repair procedure has been adopted as a standard procedure to prevent the rejection of tubes due to damaged tube ends. Tube ends are salvaged from tubes rejected for other reasons and are reconditioned to supplement the stock of new tube ends.

Table 1 gives a summary of the tube rejections showing the service hours and the number of tubes rejected for each reason. With the exception of the tubes retired from service due to exceeding the service hour limit, more tubes are rejected for increased outside diameter, or bulging. After the tubes are cleaned, the inside diameter is micrometered and the tubes are inspected internally with a light. When the tubes are removed and sand-blasted, the outside diameter is micrometered and tubes are rejected if the outside diameter has increaesd beyond 4.560 inches. At the present time, all tubes are removed from the furnaces every four months and sand-blasted, inspected and reconditioned. Enough reconditioned or new tubes are kept ready for service to completely retube one of the furnaces. To reduce the rejections due to bulging and to further reduce the possibility of failure in service, the tubes now are to be installed selectively. Tubes having the least service hours are to be installed in the fired end of the furnace with the other tubes installed in order of service hours toward the cooler end of the furnace. In addition, tubes with more than 40,000 service hours are to be installed in only the cooler half of the furnace. This should delay the bulging until the tubes approach the service limit.

TABLE 2

Summary of Tubes on Hand

Service Hours	Installed In Furnace	Reconditioned Spares	To Be Reconditioned	Not Yet Inspected
20–25,000	0	2	0	0
25–30,000	2	0	0	2
30–35,000	8	1	3	2
35–40,000	23	1	7	0
40–45,000	6	0	0	2
45–50,000	33	0	9	5
50–55,000	23	0	27	4
55–60,000	33	6	2	0

Table 2 gives a summary of the service records of the tubes now in the furnaces and the ones already reconditioned or in the process of being reconditioned for use as spares.

The fact that there have been only two tubes which failed in service is of importance. This lack of failures can be attributed to the cooperation of the operating personnel in keeping tube metal temperatures below the 1200° F. maximum allowed by shutting down the units for cleaning when this limit is approached and in shutting down the units for the four months' tube inspection and to the frequent and complete inspections made on the tubes permitting detection of defects before they progress to cause failures.

Principles of Automatic Control as Applied To Natural Gas Operations

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AUTOMATIC control isp laying an ever-increasing part throughout industry, and as process difficulties increase so do those of the control engineer. There are many users of automatic controllers who have only a hazy notion of how they operate, principally because their work lies along other lines and the controllers are purely incidental to their main endeavors. Thus it will be of considerable help to them, as well as to those responsible for the maintenance of the controllers, if they have a working knowledge of the theory and practice lying behind automatic control. The purpose of this paper, therefore, is to present briefly the theory of the present-day controller, together with the means by which this theory is translated into practice.

The author, who is the Foxboro branch manager at Houston, presented this paper at the Second Annual Short Course in Gas Technology held May 27-30, 1947, at Texas College of Arts and Industries, Kingsville, Texas.

THE pneumatic controller is a device furnished with a measuring element capable of detecting changes in the variable to be controlled which translates these changes into movements of a valve capable of influencing the controlled variable.

Automatic control for the gas industry can be classified under four main types—*On-Off, Floating, Proportional* and *Proportional with Reset.* Since the floating types, as commercially constructed, have an inherent throttling range, they can be grouped with the proportional controllers.

In order to understand the different types of control action produced by these three controllers, a series of curves has been prepared in which are plotted the motion of a measurement and the resultant motion of the valve. It is particularly important to appreciate that the valve action, plotted as the lower curve, is not influencing the measurement which is the upper curve. Such a series of curves could be produced by physically moving the measuring pen in a controller and recording the resultant changes in output air pressure while the instrument is disconnected from the valve. The purpose of the curves is to show what the control mechanism is designed to do, rather than to show the result of this action when it influences the measurement.

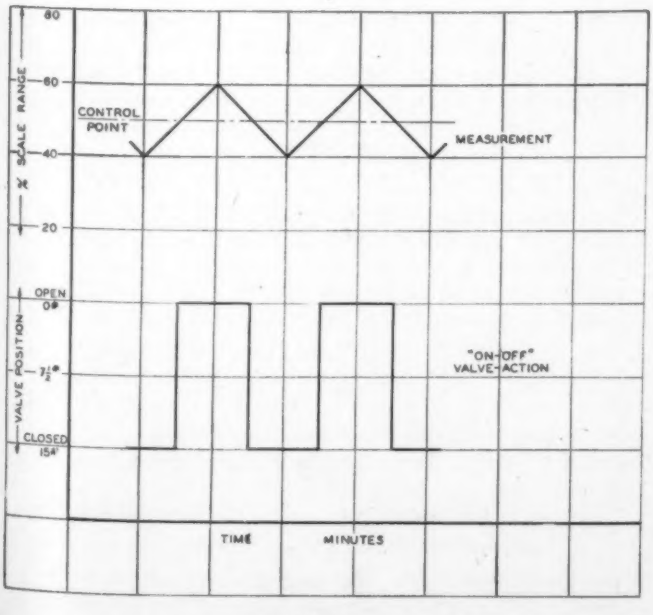

FIGURE 1

On-Off Control

Figure 1 illustrates the valve action given by an on-off controller whose measurement is responding to the changes shown. It will be seen that a valve action occurs only as the measurement crosses the control point and that the valve then operates from one extreme to the other. For all positions of the measurement above the control point the valve has one position, and for all positions below the control point the valve has another position.

It follows, therefore, that the measurment of an on-off controller must be continually cycling when it is in operation; otherwise, the valve would remain at either the open or the closed position. When applied to processes suited to this type of control the amplitudes of the cycles are so small that the record may be considered a straight line, and this type of control is, therefore, satisfactory. There are many such applications such as the temperature control of a large mass by the periodic admission or removal of heat. A common illustration of this type of control is the thermostat in an ordinary home, which measures the temperature in the room and, if the measurement is low, turns on the furnace and keeps it running until the measurment has reached the control point, at which time the furnace is shut off again. When the measurement again drops below the control point the furnace is turned on, and so the cycle continues.

Proportional Control

In the following discussion of the motions and changes in output pressure of a controller it will be assumed that the output pressure of the controller is at all times within the limits of 0 to 17 pounds. It is always possible to move the measurement so much that the air pressure reaches one of these limits, but this means that the controller has

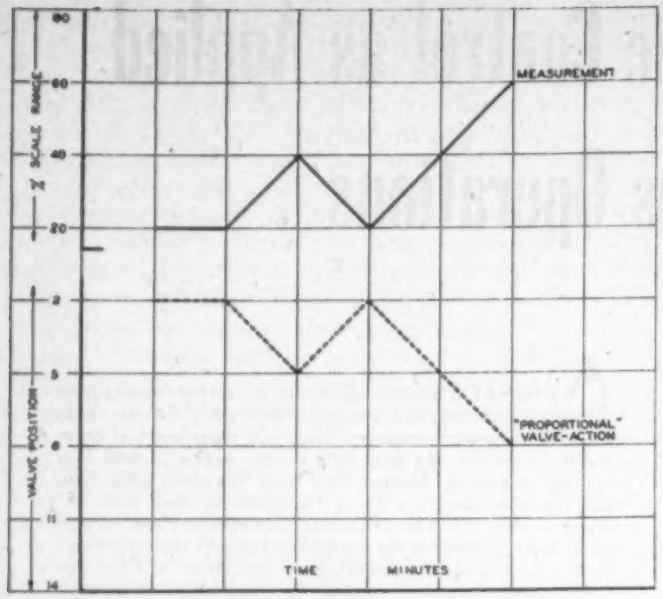

FIGURE 2

gone out of its working range, and consequently, the relations between air pressure and measurement motion which have been established need no longer remain as stated.

A proportional controller whose measurement is moving at a constant rate produces a valve action such as is shown in Figure 2. The difference between this and the on-off controller is at once apparent as, in the former case, the valve moves intermittently, while in the present case the valve continues to move as long as the measurement is moving, assuming that the valve does not reach the limit of its stroke. At any time the amount of valve movement is directly proportional to the amount of measurement movement, and it is in a direction to oppose the motion of the measurement. The valve position always bears a fixed relation to the measurement and the peak value in valve motion occurs at the point of greatest measurement deviation.

In the conventional proportional type controller it is possible to vary the amount the valve will be moved by a given measurement change by adjusting the proportional band of the instrument. The proportional band of a controller is defined as being the percentage of the scale through which the measurement must move in order to produce a travel of the valve from one extreme to the other. Thus a 100 percent proportional band controller is one where 100 percent scale movement of the measurement is required to give 100 percent valve movement.

It is important to realize that with a proportional controller each valve position is related to a definite position of the measurement. The controller may be adjusted so that the valve is positioned to bring the measurement to the desired value but the measurement will be maintained at this point only as long as there is no change in load or other variables. If, for example, the pressure drop across the valve changes, then it must assume a new position in order to pass the original flow and, therefore, the measurement must first move to a new position which necessarily will be away from the control point. This drift from control point with load or condition change is defined as "off-set" and, depending upon its magnitude and upon the process requirements, may or may not be objectionable. It follows logically that when the proportional band of the controller is narrow the off-set on normal changes in load will be small, whereas if the proportional band is wide then the off-set becomes correspondingly larger.

Proportional With Reset Control

Where operating conditions and the proportional band of the controller are such that the maximum off-set is within the permissible variations of the controlled medium the proportional controller is satisfactory. When this condition is not satisfied it becomes necessary to add a second function to the controller to overcome these objections. This function is commonly called "reset". Figure 3 illustrates the pure reset action for a sustained measurement deviation, showing that while the measurement is deviated a given amount the valve continues to move at a constant rate. Figure 4, on the other hand, shows the reset action but on an increasing measurement deviation, emphasizing that as the deviation becomes greater the rate of reset is increased. In the case of Figure 3 the fixed deviation "a" has produced a rate which is measured by the fixed angle X; and in Figure 4 as the deviation increases the rate of correction increases and reaches a value measurment by the angle between the tangent to the curve and the horizontal, which is again X; when the deviation reaches the value of A.

If we combine the proportional and reset functions in a single controller, the valve action for an increasing deviation will be the sum of the curves, Figures 2 and 4, which can be superimposed as shown in Figure 5. The important point to be obtained from this figure is that there are two distinct reactions produced by a given measurement change. The *amount* of corrective action due to the proportional action will increase only as the magnitude of deviation increases, whereas the *amount* of corrective action due to reset will increase as the magnitude and *duration* of deviation is increased; or in other words, one correction is governed by the magnitude of the deviation, while the second is governed primarily by the duration of deviation. Figure 6 shows combined curves from Figure 5 for proportional and reset and

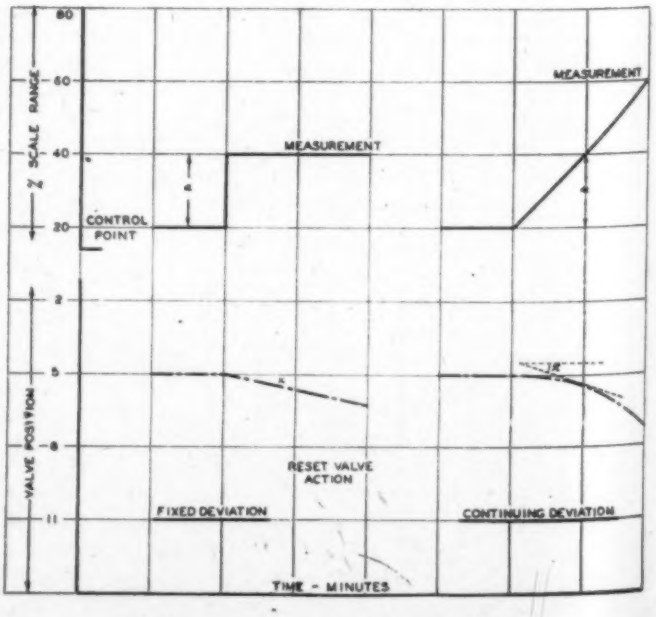

FIGURE 3

FIGURE 4

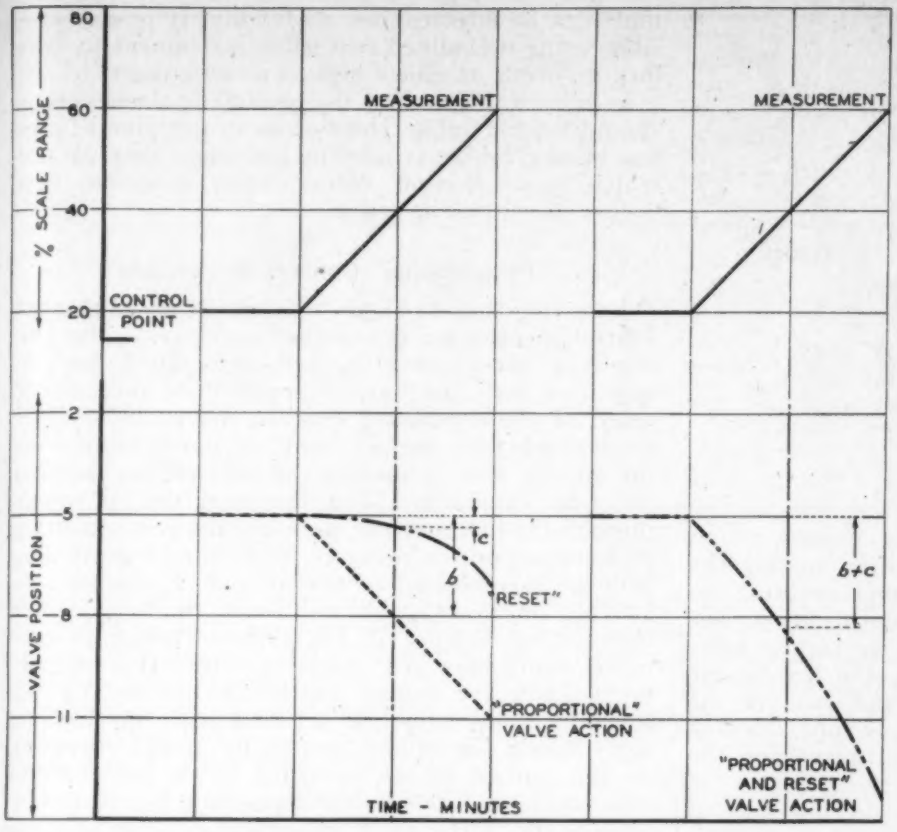

FIGURE 5

FIGURE 6

is the action which will be given by a conventional proportional and reset controller.

In Figure 7 is shown the motion of a measurement together with the motion of the valve, but in this case, and unlike the previous curves, the measurement is being controlled by the valve. The initial movement of the measurement was caused by a sudden and sustained load change of considerable magnitude. The valve reacted to restore the measurement to the original control point, and it will be seen that the measurement was returned to the control point with a minimum of cycling. It will be noticed also that the valve had assumed a new position when the measurement had been returned to the control point. The original motion of valve responding to the motion of the measurement was due to the proportional action; but the departure of the valve to its new position from its original one was due entirely to reset. Had the controller been a simple proportional type where the position of the valve is related directly to the position of the measurement, the load change would still have called for a new valve position but this could only have been obtained with a sustained deviation of the measurement. The system would therefore have been stabilized with **both** measurement and valve in new positions, unlike the reset controller which will place the valve in a new position with the measurement still at the control point.

The foregoing discussion will establish the action that may be expected from the three commonly used types of pneumatic controller, and we can now re-examine these actions to determine just how the pneumatic equipment produces these actions.

Figure 8 shows the "on-off" control mechanism. With "on-off" action the proportioning bellows is disconnected as indicated, so no feedback occurs. For the action shown in the diagram, when the flapper covers the nozzle, pressure is built up above the diaphragm of the control relay causing it to move in a manner to cut off the vent and thus put full 17-pound supply pressure on the control valve. When the flapper leaves the nozzle, air is bled from above the diaphragm of the control relay which then moves in the opposite direction, cutting off the supply and opening the vent so that pressure on the control valve drops to zero. Opposite control action is obtained simply by moving a lever. Note that aside from the very small amount of throttling inherent in the flapper-nozzle system (less than 1/10 of 1 percent) only two positions of the control valve are possible. It is either open or shut.

Although the on-off controller is not used to any extent in the natural gas industry, special adaptations of on-off action are of considerable interest. One such case is the differential limit controller which is used for automatically cutting in a second meter run when the capacity of the first is reached.

Figure 9 is a sketch showing a differential limit controller installation of the recording type in which the limit mechanism is added to a standard flow recorder. The on-off control valve in the secondary line is positioned by the differential limit control mechanism, which is operated by the primary line differential.

The mechanism for this type of controller is shown in Figure 10. The nozzle positions are set by the high and low indexes at the differentials at which it is desired to have the secondary meter run cut in and out. For a 100-inch range meter this could be at 98 inches and 10 inches, but these settings are easily changed by external setting knobs. The index pointer (or pen arm for the recording type) is actuated by the meter bearing shaft and carries the striker arm which lifts the flappers from their corresponding nozzles when the pointer is below the corresponding index setting and permits the flappers to cover these nozzles when the pointer is above the corresponding index setting. Let us assume that the controller is being put into service. The differential pointer (or pen) being at zero is below the low index setting, so both high and low nozzles are uncovered. The spring of the lock-up unit has pulled the flapper from its nozzle and there is no pressure in the diaphragm of the control relay, so its stem is thrown to the left, shutting off the vent and putting full supply pressure on the control valve which is thus closed.

As the differential rises, the low nozzle is covered by its flapper but nothing happens, for the high nozzle and the lock-up unit nozzle are still uncovered. The differential may therefore range from zero up to just below the high index with only the primary line in service. As soon as the high index point is

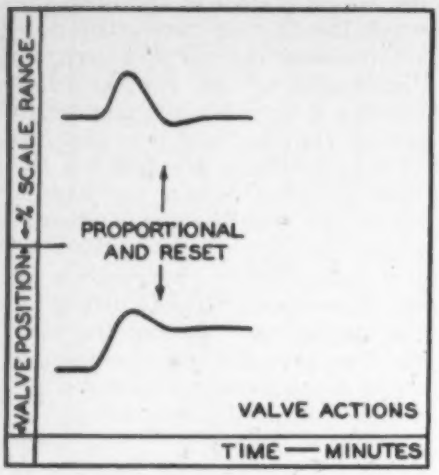

FIGURE 7

reached, however, the high nozzle is covered, which puts pressure in the pusher (1) hydron, moving the lock-up unit flapper to the right and covering its nozzle, so that pressure also builds up in pusher (2) hydron and in the diaphragm of the control relay which throws to the right, venting the line to the control valve, which thus opens and cuts in the secondary meter. Since the flow is now split, the flow through the primary line decreases, uncovering the high nozzle but nothing happens, for pressure in pusher (2) hydron holds pressure in the rest of the pneumatic system. It is thus seen that if the pointer is positioned anywhere between the two indexes, the measuring system will operate either with the primary line alone or with both lines in service.

Third Line Increases Rangeability

The determining factor is which index setting was reached last. Reverse action is obtained by changing the control relay to the opposite type. At constant line pressure, a two-run set-up as described, will handle a flow rangeability of 12 to 1, while a wide range meter set-up on both primary and secondary lines will take care of a low rangeability of 35 to 1. By using a third line, the rangeablity is increased to 180 to 1. If the line pressure falls off with increasing flow the above figures are decreased by the ratio of the square roots of the absolute pressures. If the line pressure is higher at the higher flow, the rangeabilities are correspondingly increased.

The use of the pilot type lock-up mechanism permits consistent repeatability of exact cut-on and cut-off points. One might say "they hold the control point". This is most important at the low setting since erratic cut-off at this point means a substantial loss of desired rangeability and rangeability is the very thing the differential limit controller was installed to obtain.

The same mechanism can be operated by a pressure element to open a second flow line around the primary choke of a high pressure gas well. On-off action here is imperative since throttling the control valve might mean a freeze-up.

A similar on-off type of instrument with this lock-up mechanism can be used for alarms and safety shut downs as shown in Figure 11. In such cases the controller stays locked up until manually put back in service which is done by pressing the manual release button. Although a high limit lock-up is shown here it is obvious that lock-up at a low-limit can be effected just as readily. It is also possible, using a modified two index instrument to have lock-up occur at either high or low settings.

In hazardous locations the pneumatic alarm system should be preferable. Heavy loss of gas, due to pipe line breaks, can be avoided by the use of such devices which close shut-off valves when excessive flow occurs in either direction.

"Proportional" Control Mechanism

Referring back to Figure 8, it will be noted that the control mechanism is exactly the same as the On-Off type except that the proportioning bellows is now tied into the output pressure of the control relay. If the measuring element moves the pointer to the right, the flapper tends to move away from the nozzle, thus decreasing the pressure on the control relay diaphragm. This decreases the air supply through the ball seat and increases the vent, resulting in decreased output pressure. Since the proportioning bellows is connected to this output, it contracts to hold the nozzle in proper relation to the flapper, thus maintaining balance in the system. When proportional controllers are operating within the proportional band, the flapper and nozzle are always just touching. This must be so, otherwise the control relay would put either zero or full supply pressure on the control valves, resulting in its being either wide open or fully closed depending on its action. The width of the proportional band is changed by varying the loading of the proportioning spring which is a circular cantilever type. Opposite control action is obtained in the same manner as described under "On-Off" Control. The proportional band can be adjusted from ¼ of 1 percent to a maximum of 10 percent of the indicating scale.

Proportional control is commonly used in the gas

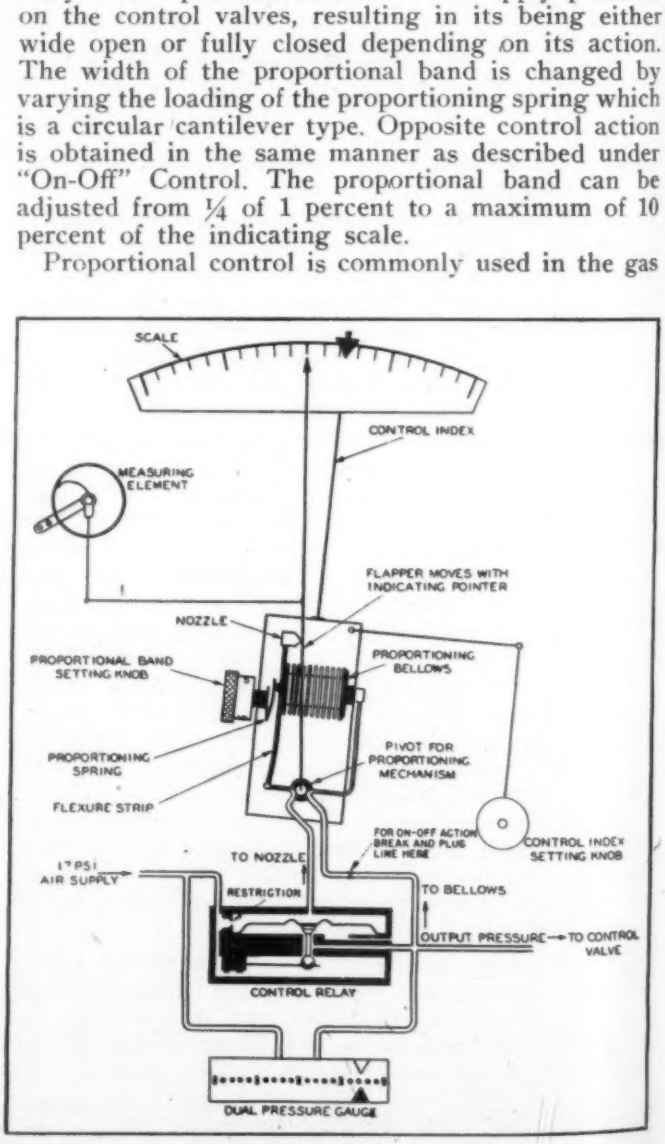

FIGURE 8

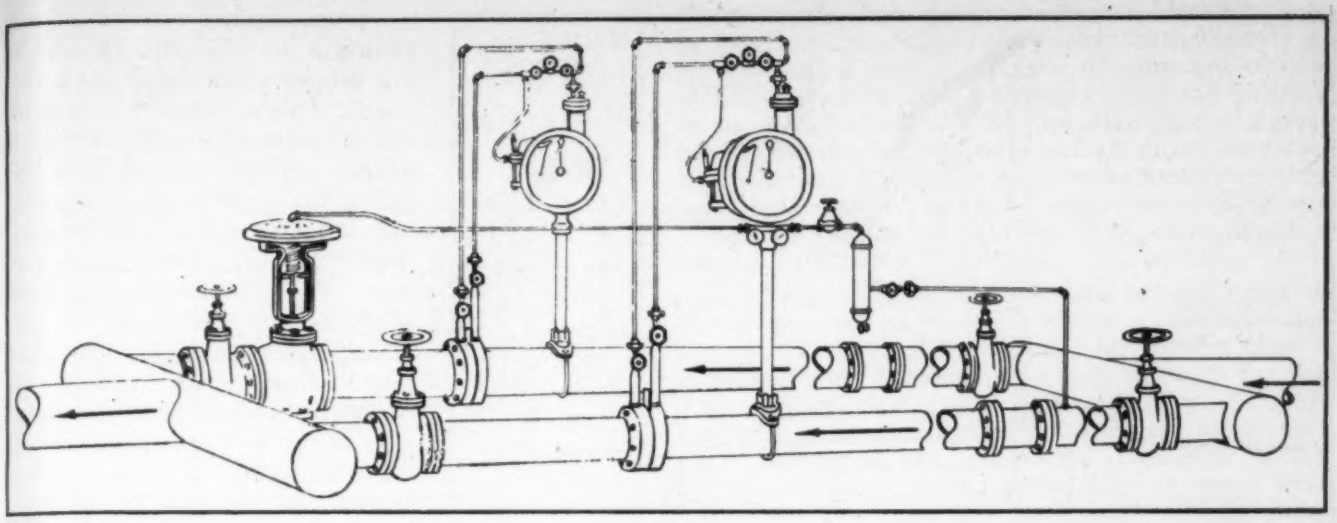

FIGURE 9

industry where most applications involve pressure control and require comparatively narrow throttling ranges with consequent small "offset" or drift from the desired control setting.

Proportional pressure controllers are often used in conjunction with weight loaded regulators to provide closer control.

When used for this application, the instrument is called a *Pressure Sensitizer*. Two main types are used. The constant pressure type with adjustable index setting and the time-cam type. The former is used where it is desirable to maintain closely a pre-determined pressure setting. Under changing load conditions, most weight-loaded regulators permit substantial changes of controlled pressures; so in order to maintain the output pressure closely, it would be necessary to have an operator constantly in attendance to increase or decrease the weights on the regulator arm.

Figure 12 shows how the pressure sensitizer does just that. The instrument, a proportional type controller, as decribed previously, operates through a diaphragm motor lever to increase or decrease the loading of the regulator. This motor lever arm is attached through a chain and turnbuckle to a slotted yoke which carries sufficient additional loading weights to hold maximum pressure at maximum demand. Minimum pressure at minimum demand is set by the regulator weights alone—that is with the yoke mechanism and its loading weights lifted from the regulator arm. Between these two extreme conditions the pressure sensitizer acts continuously to vary the loading so as to maintain very closely the desired output pressure. If the controlled pressure tends to drop, the instrument bleeds pressure from the diaphragm motor, thus increasing the loading on the regulator arm. If the pressure tends to rise, the opposite happens. Note that in the event of instrument or diaphragm motor trouble, this set-up fails "safe"—that is, it loads the regulator arm to the maximum and the regulator carries on at the high pressure.

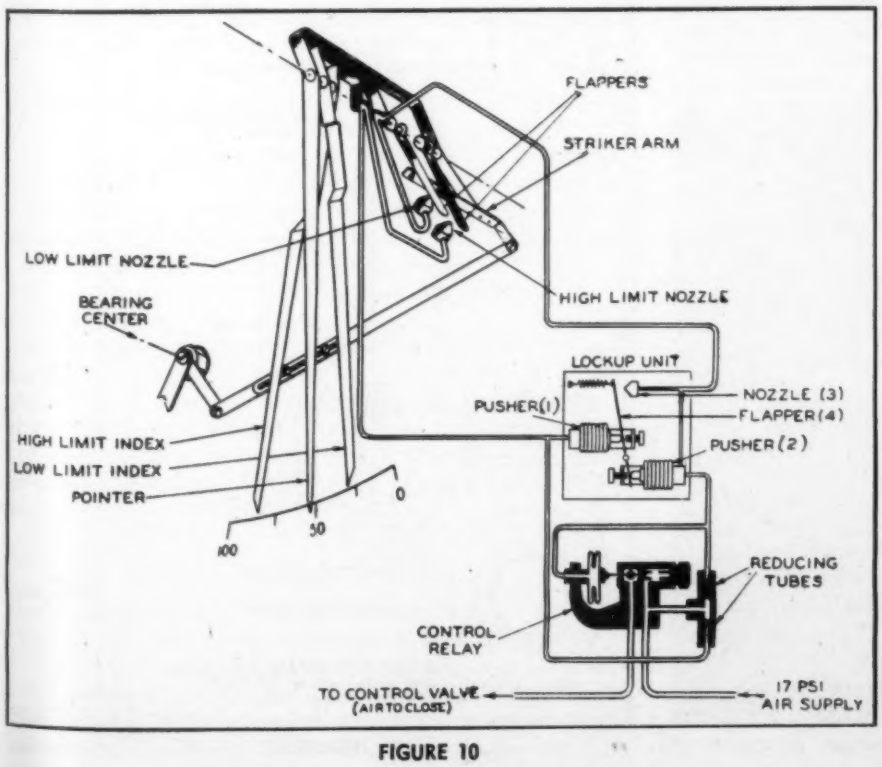

FIGURE 10

The time-cam type of pressure sensitizer is similar except that the output pressure is changed in accordance with a pre-determined schedule which is cut out on an aluminum cam which is rotated by a clock so as to hold a given pressure at a given time. Figure 13 shows this hookup which is sometimes used at town border pressure reducing stations, for packing transmission lines in advance of loads, and similar applications where a desired time-pressure schedule can be worked out. Seasonal variations of the schedule are handled by the changing of cams.

The proportional type of flow controller can be used for controlling the amount of gas injection into wells for pressure maintenance or re-pressuring when load conditions are fairly steady. If the control valve is installed upstream from the orifice plate, pressure at

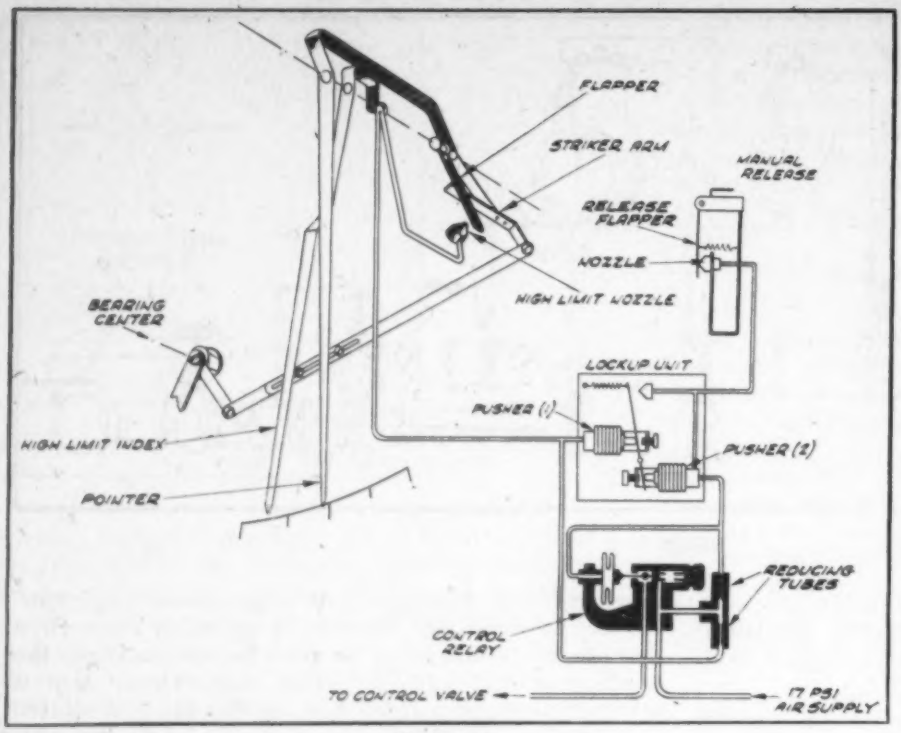

FIGURE 11

the orifice is comparatively constant so that the instrument actually becomes a volume controller although it controls only the differentials across the orifice plate. Figure 14 shows orifice flanges, connections and control valves on three lines going to gas injection wells.

"Proportional With Reset" Control Mechanism

It is desirable or necessary in many processes, for the instrument to hold a predetermined set point with no drift. This is particularly true in control problems where wide proportional bands are necessary to prevent cycling and where very close control is essential for satisfactory plant operation. Since with proportional control we have a band of control instead of a control point, proportional controllers are not suitable for such processes, as even moderate changes in demand or supply would result in substantial changes in the value of the controlled variable. A control action, designed to return the controlled variable to the set point, is called the *Proportional with Reset* type. The nozzle assembly is fixed as concerns vertical or lateral motion, but can be rotated to change the width of the proportional band and to obtain the opposite control action. The flapper is operated by the contact arm which is moved by the proportioning lever and this in turn receives its motion from the measuring element. The simplest way to explain the action of this type of controller is to assume that the process is in balance with control maintained at the set point and with, say eight pounds pressure on the control valve diaphragm and in the proportioning and reset bellows. If a disturbance occurs causing the measuring element to read higher, the top part of the proportioning lever will be moved to the left, pivoting about the lower end of this lever. This will cause the flapper to more nearly cover the nozzle and thus put more pressure on the diaphragm of the control relay. The supply valve in the relay will open wider increasing the output pressure, until this pressure increase in the proportioning bellows is just sufficient to hold the flapper in the proper relationship with the nozzle. This increased pressure in the proportioning bellows establishes a differential pressure between the proportioning and reset bellows. This differential pressure is proportional to the pen deviation. The differential pressure produces a flow through the adjustable reset resistance into the reset bellows. As the pressure in the reset bellows rises, the pressure in the proportioning bellows must also rise the same amount in order to maintain the differential pressure as established by the pen deviation. This resetting effect will continue until the measurement returns to the set point, because only when this occurs, the pressures in the proportional and reset bellows become equal and equilibrium is again restored. From the above, it is apparent that the controller is now operating with a different valve opening but control is still at the set point. In other words, instead of the control point shifting in the proportional band with change

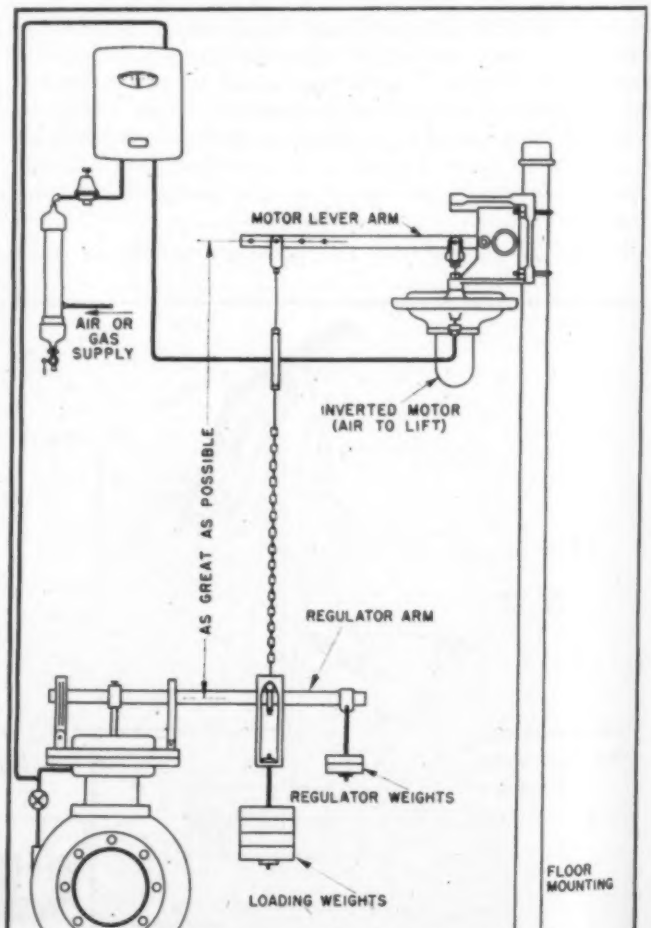

FIGURE 12

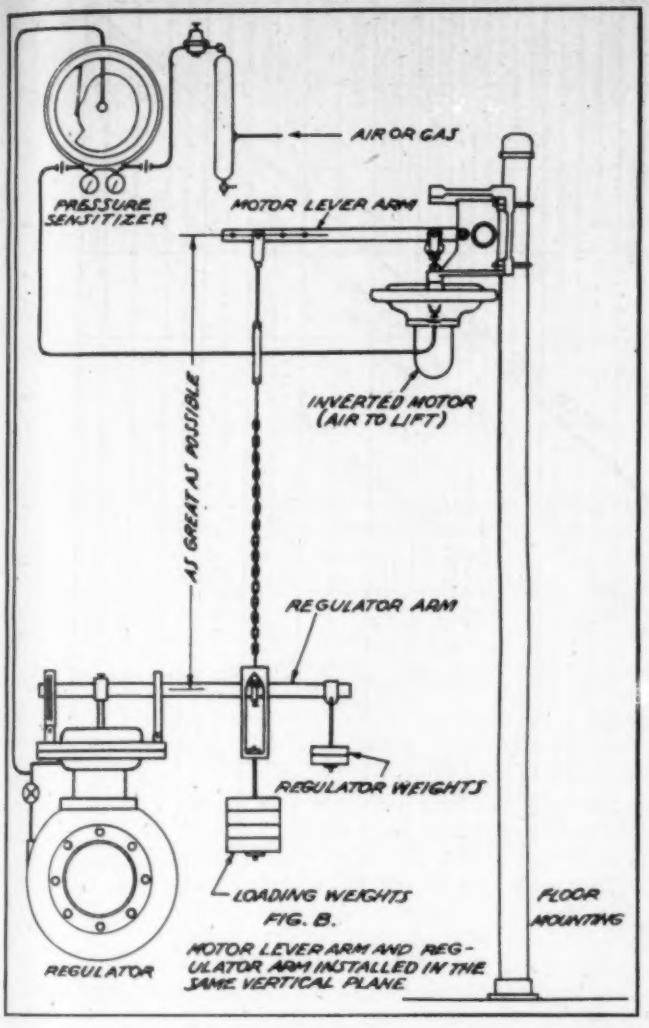

FIGURE 13

in load, the proportional band actually shifts about the control point.

Flow ratio controllers should be the *proportional with reset* type since close control is generally required under varying load conditions. This instrument consists of two meter bodies mounted on one case in which is a mechanism for varying the desired ratio between the two flows. The primary flow which is usually uncontrolled determines the set point of the secondary or controlled flow, and as the primary flow varies the secondary flow is increased or decreased to maintain the desired ratio between the flows. The ratio setting can be readily changed in the instrument. If both flows are controllable, the solution, of course, is to use two flow controllers.

In compressor control with control effected through the engine governor or by a control valve in the steam line of the engine, the application requires a rather wide proportional band. Since load changes may vary widely and since close control is advisable, the proportional with reset type of control is recommended.

Control Valves

In the same way that a flow meter needs a primary device in the line for a complete metering set-up, so an instrument type controller needs a control valve to complete its installation. With "on-off" controllers, capacity and tight shut-off are the essential valve characteristics. With throttling conrollers—proportional or proportional with reset—consideration must be given to the changes that occur in the supply of the controlled medium—that is, the amount of correction—when the valve changes from one position to another. For the simpler processes (and gas pressure regulation is ordinarily one of them), satisfactory valve characteristics may not be too critical, but in the more difficult processes where unfavorable lags complicate the control problem, valve characteristics assume substantial importance.

Figure 15 shows flow curves of several types of valves plotted on semi-log paper. The ordinates reading "Percent of Total Lift" might also have a scale reading "Pressure on Diaphragm of Control Valve." The heaviest line has what we call equal percentage characteristics. By that we mean that equal changes in pressure on the diaphragm of the valve increase or decrease the flow by equal percentages of the existing flow regardless of the valve position at the time of the change.

For example, at 10 percent lift the flow through the valve is 2.75 percent of maximum. At 20 percent of lift—that is, after a certain increase in diaphragm pressure—the flow becomes 4.1 percent of maximum, or an increase of 50 percent over the previous flow. Farther up the scale, for example, at 40 percent lift, the flow through the valve is 9.2 percent of maximum and with the same increase in pressure, that is, to 50 percent, the flow becomes 13.8 percent of maximum, which is again a 50 percent increase over the previous value. At a third point on the scale, namely, at 80 percent of lift, the flow through the valve is 45 percent of maximum, and at 90 percent of lift—again the same increase in pressure on the valve—the flow becomes 67.5 percent of maximum, once more resulting in the 50 percent increase over the previous flow.

The practical value of this percentage characteristic may be brought out by examples. Let us assume a control valve in the steam line of a reboiler at a natural gasoline plant and the process balanced with say 10 pounds pressure on the diaphragm of the valve and a certain pressure drop across the valve. A given process disturbance requires a 10 percent change in steam flow to keep the process balanced. At another time the steam supply pressure may be

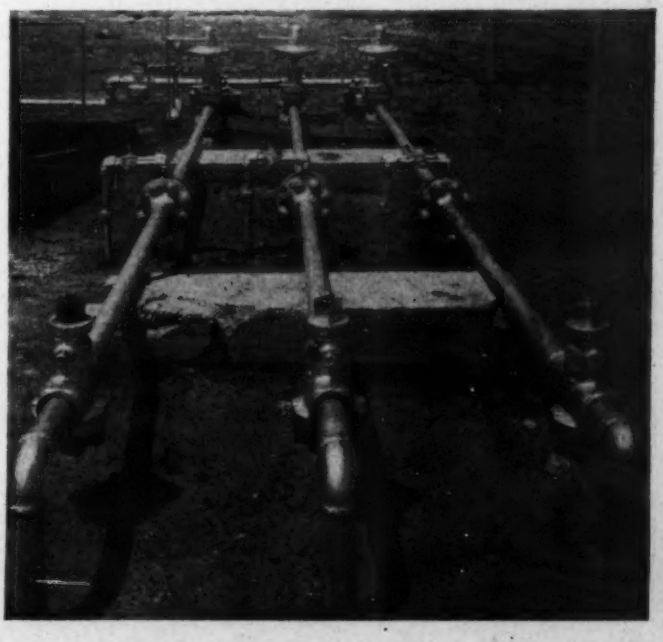

FIGURE 14

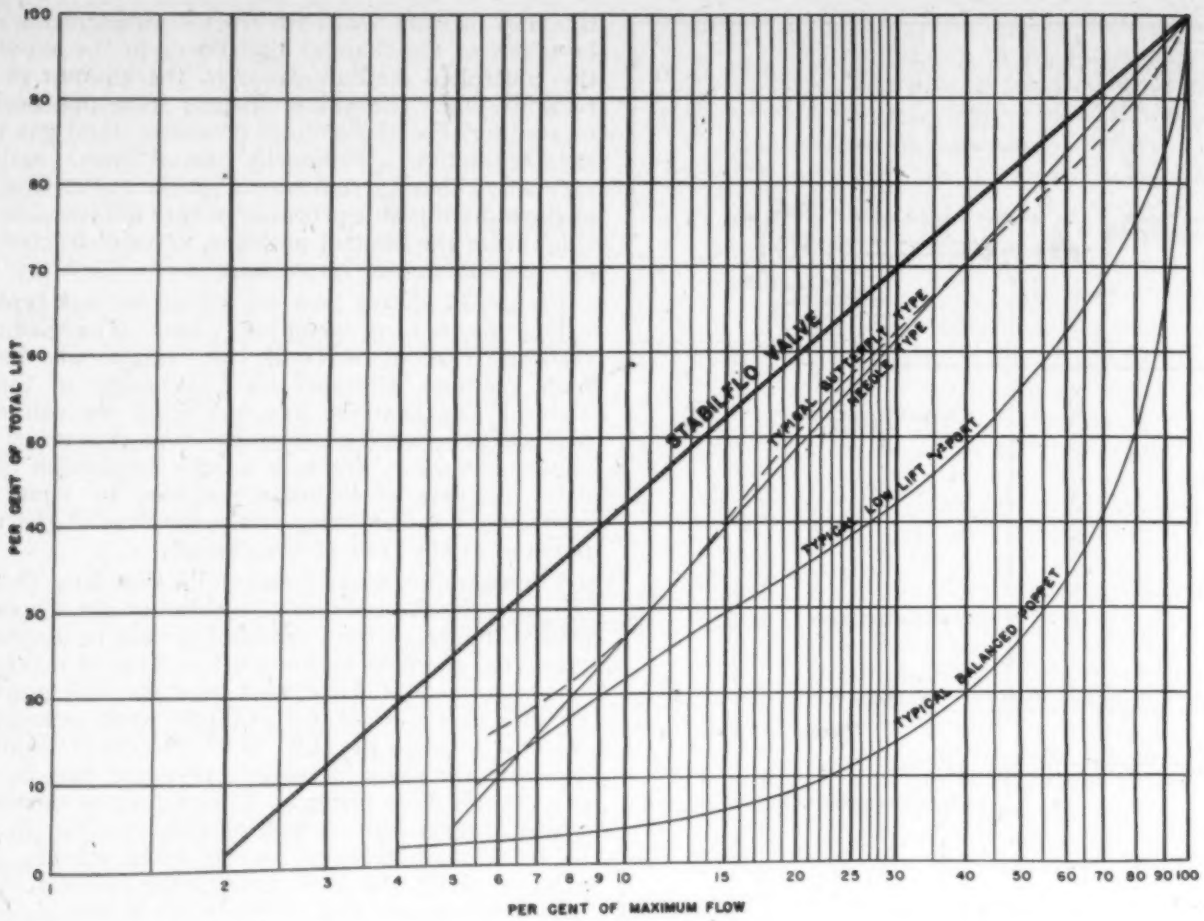

FIGURE 15

lower, so the same valve, in order to pass the same amount of steam, must be open wider as the pressure drop across it is less. If the same disturbance as mentioned above now occurs, the same 10 percent change in steam flow is required, and the instrument to correct for this disturbance will call for the same output pressure change resulting in the same corrective effect to rebalance the process.

Figure 16 shows a similar plot except that valve lift is plotted against rate of flow. Valve sizing becomes a rather minor consideration with equal percentage valves of wide rangeability. For example, if a 2-inch valve is operating at 78 percent lift, a 3-inch on the same application would operate at 58 percent lift to pass the same flow. Now if a change in load occurs, that would cause the 2-inch to drop to 64 percent lift, this change would, of course, affect the 3-inch in a like manner. To decrease the flow the same percentage, the 3-inch would change to 44 percent lift, an equal percentage decrease. In other words, triangles *ABC* and *DEF* are similar and equal. Hence, no change in controller adjustments need be made if one valve should be substituted for the other. While oversize control valves are not to be encouraged, it is interesting to note that the wide rangeability—equal percentage—type just described will handle such control problems entirely satisfactorily.

It is thus evident that the equal percentage characteristic has much to recommend it. Correct sizing is not critical (providing the size is ample for maximum demand) and rangeability is increased without the necessity of changing the controller settings.

In conclusion, we have seen that "on-off" control, although more widely used in general industrial applications than any other type, has little application in the gas industry except for special types of situations. For this industry the proportional type is used and is generally satisfactory if a narrow proportional band can be used. Where a wide proportional band is necessary, or extremely close control is essential and widely changing load conditions are present, then the proportional with reset type should be specified. Control valve characteristics should receive careful consideration on all control problems involving unfavorable lags.

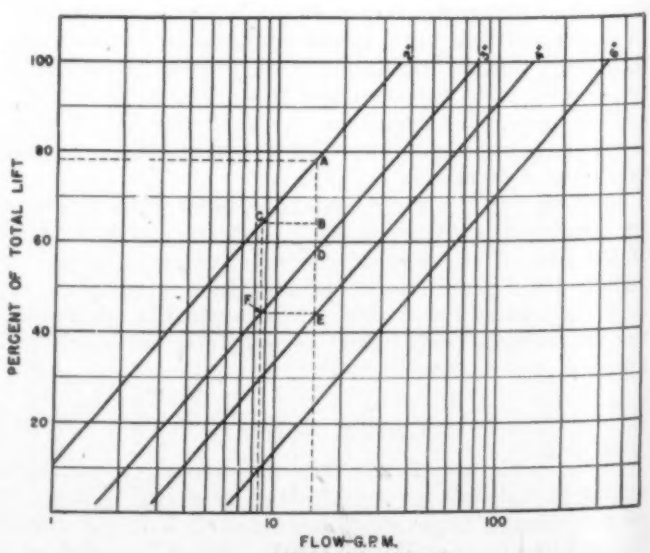

FIGURE 16

Internally Insulated Piping and Pressure Vessels for High-Temperature Service

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THE tremendous amount of petroleum process research in recent years has posed many varied mechanical design problems. Economically satisfactory resolution of new major problems is essential to successful commercial application of a process. One important tool is internal insulation for lines and vessels required to operate at sufficiently high temperatures to render the use of bare metal either impractical or exorbitant in cost.

Actual application is complex because of the large number of variables such as cyclic temperature or pressure, corrosion and erosion, and limitations imposed by the characteristics, manufacture, fabrication, erection or maintenance of both insulation and metal. Four examples are given.

The design of fixed bed reactors and the recirculating catalyst regeneration system for the first commercial Hydroforming unit was very difficult. Economics dictated carbon steel with internal insulation for both the reactors and regeneration piping. The insulating block and brick reactor liner failed and was replaced with suspended refractory tile which is satisfactory. The regeneration piping was protected with a cartridge type liner packed with insulation but maintenance was excessive. Improved liner material and pumped plastic insulation corrected the situation.

Hydroforming unit experience, though largely negative at the time, led to successful and economical suspended refractory tile lined regenerators in fluid catalyst units. Seventy-two inch i.d. catalyst lines presented several problems. Lapped sectional carbon steel lines backed by insulating block were successful except at points of extreme turbulence. Longer sections with plastic insulation pumped into the annular space provided an economic solution.

This paper was presented at the annual meeting of the Petroleum Section, ASME, in Houston early in October.

THE rapid expansion of metallurgical and engineering research in recent years has provided the design engineer with many new materials and methods with which to meet equally numerous mechanical problems. The great acceleration and amplification of chemical and process research in the petroleum and chemical fields has produced a multiplicity of potential commercial processes, many of which may be unduly limited or even eliminated unless material and structural problems can be resolved. The fields encompassed are often so ramified that the final mechanical solutions require extensive studies involving the coordinated investigation of design, manufacture, fabrication, erection, and maintenance provisions. If existing materials or methods are inadequate or too costly, the development of new approaches may be essential. When the field is quite new and information is limited, the initial construction may be somewhat lacking, thus necessitating changes to render it entirely satisfactory.

Internal insulation for vessels and piping is a tool which has enabled satisfactory and economical construction for a number of quite different processes. This paper is not a learned treatise on the subject but rather an analytical discussion of the numerous factors involved and a demonstration of a few widely divergent problems and their solutions. The examples represent the combined engineering contributions of many individuals in numerous companies.

Basic Considerations

The design of any permanent pipe or vessel must assure that it will be safe, operable, maintained economically, and constructed at the minimum compatible cost. In order to meet these requirements, construction must be based on consideration of the following fundamental factors:

Temperature-Pressure—If cyclic; speed, range, and frequency.
Corrosion—Including possible future changes.
Erosion—Including possible future changes.
Materials—Metallurgical possibilities; manufacture; fabrication; erection; and reliability.
Legal aspects—Code and law compliance.
Investment cost.
Maintenance cost.
Penalty for repair shutdown time.

Often this list alone is not as formidable as it may appear since a given set of conditions may narrow the possibilities considerably, thus automatically simpli-

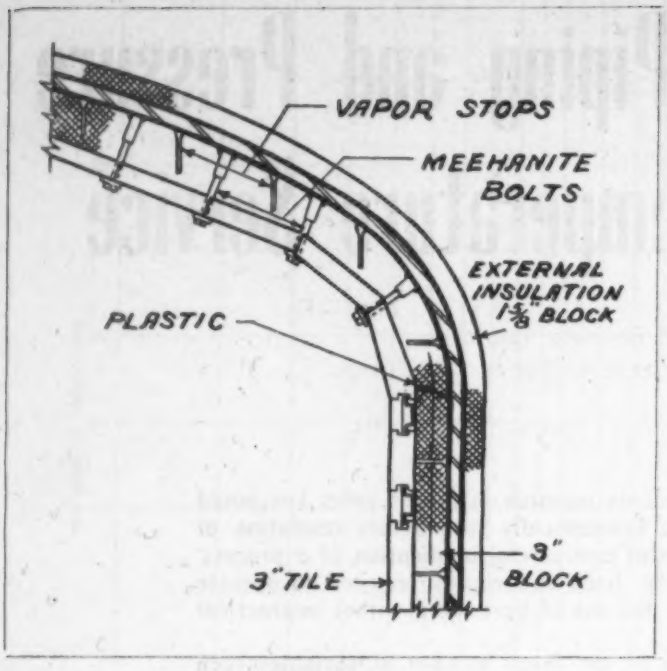

FIGURE 1
Hydroforming Reactor Insulation

fying the approach. However, other engineering considerations may enter into and complicate a specific solution. The advent of very large lines and vessels for high temperature operations has increased the complexity of selection tremendously, largely because of departure from fields of prior experience and the cost or unavailability of suitable alloy steels. Such cases require considerable exploration, development of methods, etc., thus taxing the ingenuity of the designers and experts in various material and equipment fields. Examples of problems encountered in two different petroleum processing fields and involving the use of internal insulation are presented in the following discussion.

HYDROFORMING UNIT—Vessels

This process improves the octane number of low octane naphthas or produces commercially recoverable quantities of mixed aromatic solvents by catalytic treatment in fixed bed cyclic reactors. The first commercial sized unit designed and constructed in 1939-40 presented numerous major design problems which were amplified by the fact that for the first time in the history of the modern petroleum industry a full sized unit was designed directly from small pilot plant data without the previously employed intervening step of a semi-commercial installation. The reactors and regeneration system, only, are pertinent to this paper.

The unit involves the use of two 14′—9″ x 16′—6″ downflow reactors alternating approximately every six hours on process and regeneration. During reaction vaporized naphtha and recycled hydrocarbon gas containing a high percent of hydrogen are charged at a temperature of roughly 1050° F. and a pressure of 315 psig. These vapors are purged with hydrocarbon gas at 700° F. and 315 psig and then with inert (oxygen free) flue gas at 1000° F. and atmospheric pressure.

Regeneration is effected by repressuring to 100 psig and introducing a small amount of oxygen into 650° inert gas and thus gradually burning off the carbon and oxidizing the partially reduced catalyst with a resultant reactor exit temperature of 1050° F. This also removes part of the sulphur compounds which the catalyst has removed from the hydrocarbon stream. Hence, the reactors must be suitable for:

Cyclic temperatures—650-1050° F.

Cyclic pressures—0-315 psig.

Vapors containing considerable percentages of methane and hydrogen.

Flue gas containing sulphur compounds.

The combined factors of plate and nozzle thickness and cyclic temperature shock indicated immediately the necessity for either internal insulation or the use of an absurdly large number of small diameter reactors. Costs then showed two reactors to be the most economical. The possibility of decarburization due to the hydrogen also favored internal insulation in order to achieve minimum vessel metal temperatures. Carbon steel was determined to be satisfactory for the vessels, which were designed in accordance with the API-ASME code for 650° F. maximum temperature on the basis of X-ray and stress relief. This left the problem of developing an internal insulation which would: have adequate insulating value at the various temperature-pressure conditions to limit metal temperatures to 650° F. yet prevent flue gas condensation on the metal; have strength to take pellet catalyst bed expansion loads at elevated temperatures; be unaffected by sudden depressuring; not permit by-passing of gases around the bed; be sufficiently impervious or very pervious to prevent pocketing of flue gas condensate against the shell during starting up and shutting down operations; and be unaffected by such condensate.

These conditions were presumed to be met by lining the vessel with 4½ inches of insulating brick and providing 1⅝ inches of external block insulation. Actually, within less than a year top head temperatures became excessive due to joints opening and consequently by-passing of vapors behind the brick. Replacement was made with ¼ inch of plastic insulation against the dome metal followed by 2 inches of dense high temperature insulating block, another layer of plastic and the brick. Nine concentric rings of 12-gauge type 304 18-8 ohrome-nickel were provided as vapor stops and as anchors for 18-8 J-bolts which with 3-inch square washers supplemented by 18-8 wire mesh retained the brick. The 30-inch I.D. top manway and 24-inch vapor inlet on its side were protected with plastic, ½ inch of block and sectional 18-8 liners.

After two years of service localized top temperatures in excess of 650° F. were experienced, caused by vapor by-passing due to cracking of the 18-8 vapor stop welds and embrittlement apparently resulting from carbide precipitation. Also some upper shell temperatures increased to an undesirable point because of brick joint opening and vapor by-passing. The former difficulties were corrected by patching and the latter by re-laying the obvious sections and sealing cracks with two coats of refractory cement.

About a year later, a sizable crack developed in a longitudinal welded seam in the top ring of one reactor. Both vessels were stripped and weld overlays, which were permitted by the code when built, were chipped and ground smooth. All seams were magnafluxed and numerous cracks were chipped and rewelded. Repairs were within the code range

not requiring stress relief. The linings were replaced as last described but shortly thereafter high temperatures developed on one upper shell and a crack occurred in a top manway flange.

Plastic Installation Installed

Prior to this time, exchange of information with others who were experiencing similar difficulties with various similar or modified liners had led to the conclusion that the problem was general and not easily solved. Study narrowed the best apparent possibilities for the vessel proper to the application of a carbon steel or 18-8 chrome-nickel liner, which had been used elsewhere with considerable success, or the possible development of a suspended refractory tile installation which had been considered seriously for a number of years. The latter appeared to offer greater ease of inspection and maintenance and freedom from expansion troubles but presented the problems of fairly high thermal conductivity, elimination of vapor by-passing, and the ability to withstand rapid depressuring.

As shown on Figure 1, all conditions were met by installing plastic insulation, 3½ inches of block and 3 inches of tile. Carbon steel vapor stops on 18-inch centers were provided throughout the shell and dome. Meehanite tile suspensions were used and for the dome these were screwed into couplings welded to the shell. Tile clearances were larger than usual in order to provide for thermal expansion plus depressuring vent openings. Magnafluxing and X-raying at this time showed no new seam cracks. The top manway and side nozzles were protected by installing a rigid liner positioned by buttons and pumping into the annular space a plastic, quicksetting, dense insulating material which expands upon setting. The material and technique are described in more detail under "Hydroforming Unit-Piping."

These facilities have given trouble-free service for more than two years. Also, it is no longer necessary to remove the external vessel insulation to maintain safe temperatures and the recorded vessel wall temperature cycle has been reduced from a sharp 700° F. to a gradual 200° F.

HYDROFORMING UNIT—Piping

Catalyst regeneration is accomplished by generating flue gas by the controlled combustion of natural gas at 100 psig, passing this through the catalyst bed to burn off the carbon, sulphur, etc., discharging the "make" gas to atmosphere, cooling of the balance by a waste heat boiler, and return of this stream to the flue gas generator by a recirculating blower. Maximum blower casing and differential pressures were limited severely by domestic and foreign large capacity blower development at the time of construction. Hence, the requirements of low static pressure and minimum pressure drop resulted in line sizes ranging from 6 to 24-inch with 20 and 24-inch predominating. Flue gas temperature ranges in typical sections were predicted to be 700-1100° F., 70-900° and 600-1050° F. With minor exceptions the pressure would normally be in the range of 90-100 psig but explosion protection of the flue gas generator by rupture discs necessitated consideration of sudden complete depressuring. Dewpoints were rather uncertain because the mechanism of sulphur removal from the catalyst and consequent chemical composition of the sulphur compounds were not fully established.

The combination of line sizes, temperature shock,

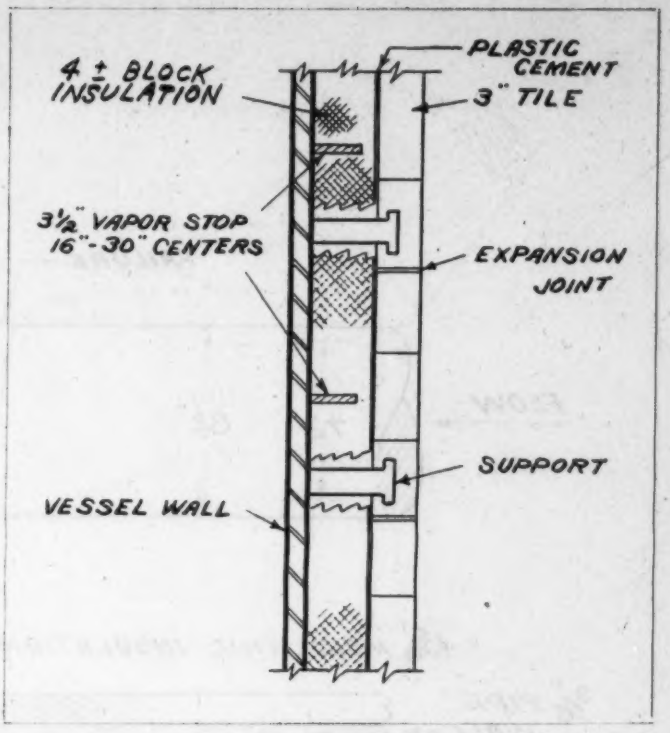

FIGURE 2
Fluid Catalyst Regenerator Wall

and uncertain dewpoints and sulphur compound composition made the use of alloy piping very questionable because of the severity of the temperature conditions, high cost, doubtful ability to select a suitable alloy, and manufacture and fabrication problems. Therefore, carbon steel piping with internal insulation was elected. A cartridge type design was used consisting of a 22-gauge carbon steel outer jacket, a 1-inch layer of packed lead slag wool and a 22-gauge 18-8 chrome-nickel liner with requisite expansion allowance and presumably adequate pressure equalization provisions.

Early in operations complete sudden depressuring damaged some of the internal liner, apparently due to inadequate contained gas release provisions. The liner was then provided with 3/16-inch perforations on 4-inch centers but this also proved insufficient when rupture disc operation again collapsed the liner. Two corrective steps were taken: The lead slag wool was replaced with a lower void content material consisting of a diatomaceous earth and amosite B-1 bound with sodium silicate; and the 18-8 chrome-nickel liner thickness was increased to 16-gauge, 1 x 4-inch circumferential reinforcing bands on 6-inch centers were added, and 3/16-inch bleed holes were provided on 4-inch centers. This installation proved reasonably satisfactory but after five years maintenance in some sections became unduly high because of liner corrosion and deterioration of the insulation. The conditions were worst in cyclically dead end sections where condensation apparently occurred in spite of circulation provisions.

Trial Installation of Insulation

All known or conceived solutions were reviewed, particularly in the light of alloy test sample data, forced use of carbon steel for liner repairs and new developments in insulating materials. The failure of 18-8 chrome-nickel to stand up, the unattractive results of test coupons of other alloys, and the

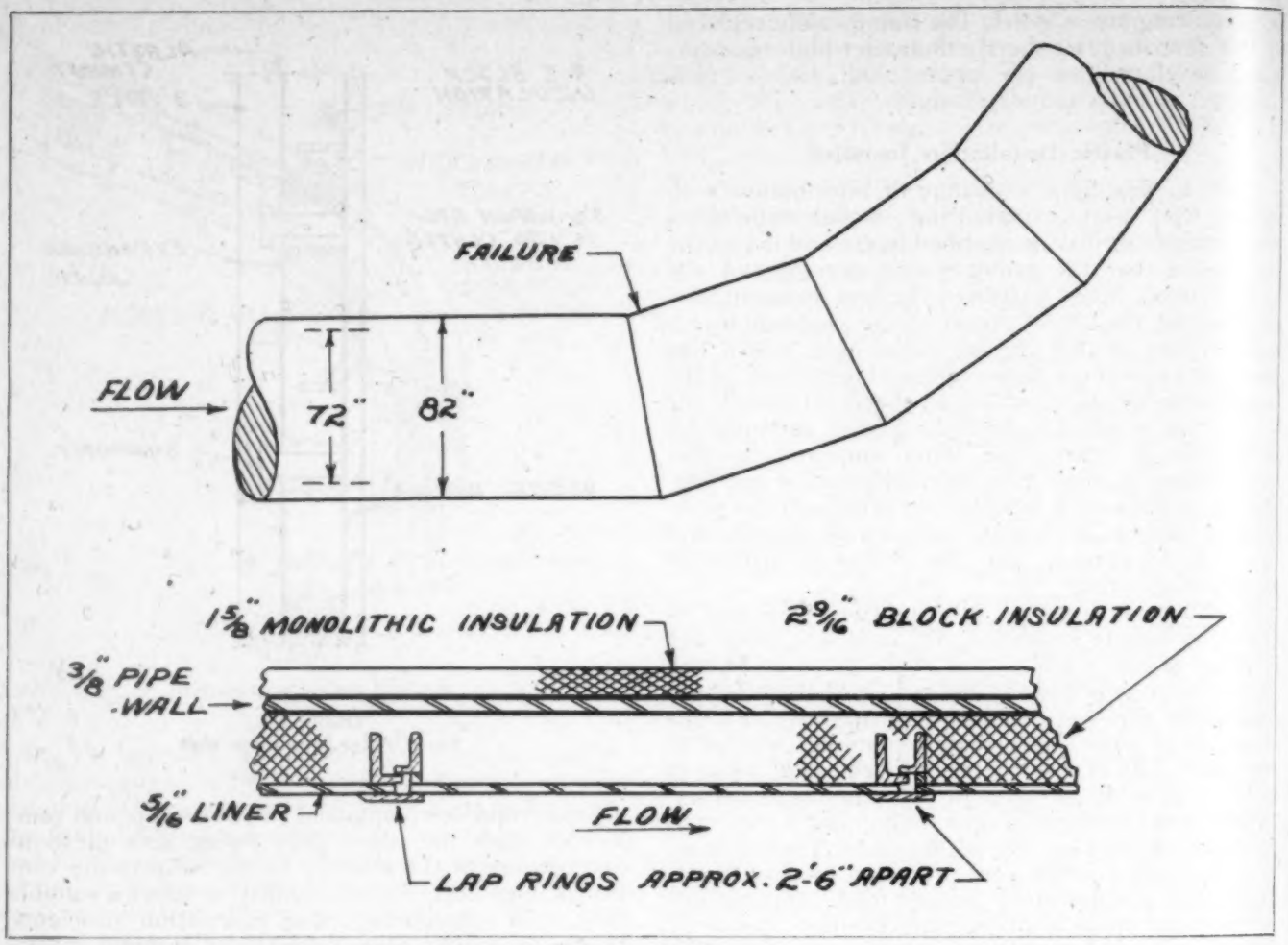

FIGURE 3
Fluid Catalyst Spent Catalyst Pipe Original

superior performance of the carbon steel liner used in repairs indicated that internal lining would be by far the least costly provided a suitable insulating material could be found. Surveys, plus recent experience, both positive and negative, in connection with fluid catalyst units showed that one promising insulation existed. This material appeared satisfactory from the standpoints of thermal conductivity, mechanical strength, low permeability to attain minimum gas absorption with consequent high elevated pressure insulating value and resistance to damage when depressured, suitable temperature expansion coefficient, toughness, the great advantage of expanding instead of contracting when setting, rapid setting and ease of placement since it could be pumped into position while in a plastic state. The action of flue gas condensate was unknown. Therefore, trial installations were made in the unit at points of severest conditions and subsequent examination plus pipe metal temperature measurements showed very satisfactory results.

The characteristics of low permeability, pumpability, and set expansion have enabled the use of a ¼-inch carbon steel liner positioned by spacers with lap ring sliding expansion joints every 10 feet. The insulation is pumped into the annular space between the liner and pipe wall and voids are eliminated by providing suitable pipe wall or liner vents during the filling process. Absorbed gas escapes through the expansion joints during depressuring and no other provisions have been found necessary.

This type of installation is now standard and is applied to each section when major repairs to the former installation become necessary. No maintenance has been required thus far and service exceeds a year in several sections.

FLUID CATALYST UNIT—Vessels

The Fluid catalyst cracking process was developed initially just prior to our entry into World War II. The development and commercial application was accelerated tremendously by its potentialities for producing large quantities of aviation gasoline components and butylenes for alkylation, butadiene manufacture, etc. Its advent presented requirements for low pressure vessels of diameters in excess of 40 feet with content temperatures as high as 1100° F. Design placed particular emphasis on the "in place" field fabrication, X-ray and stress relief of vessels having relatively thick walls. Since the scope exceeded that of experience and existing codes, the deveolpment of methods and preparation of suitable code addenda were necessary. Since extensive internal insulation was employed generally in only the regenerator, the discussion will be limited to this vessel.

The function of the regenerator is the reactivation of spent catalyst by the burning off of deposited carbon in the presence of a controlled quantity of oxygen. Execution requires intimate contacting, time element and a means of separating the flue gas from the bulk of catalyst to permit return of the latter to the process. Numerous successful designs vary in

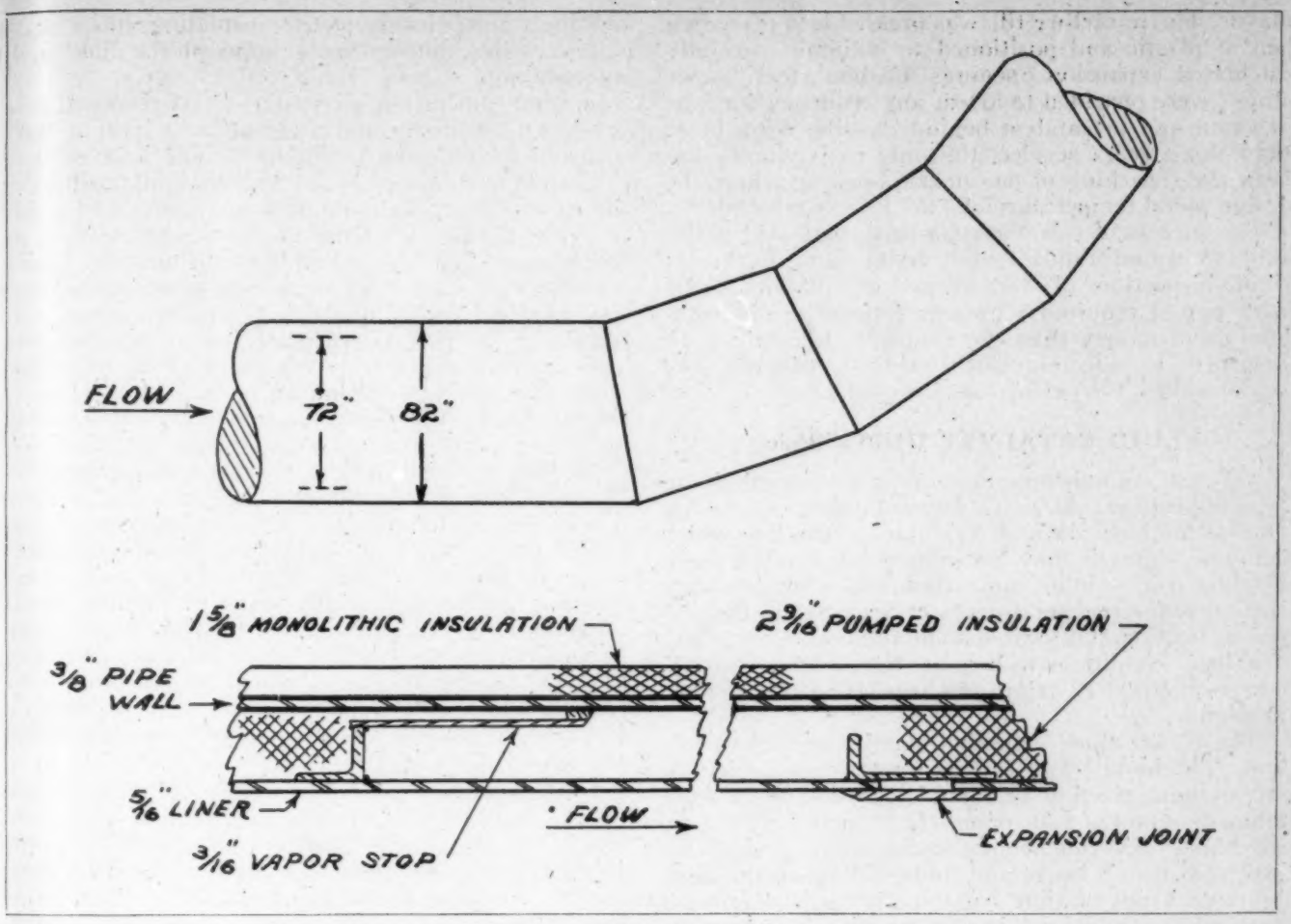

FIGURE 4
Fluid Catalyst Spent Catalyst Pipe Modified

detail but all have the common problem of providing a suitable basic vessel. To establish the order of magnitude, a representative example consists of a vessel 41 feet (i.d.) by 73 feet high and approximately 35 feet between the tangent points. Spent catalyst and compressed air are introduced near the bottom, a dense phase bed is maintained in roughly the lower half of the vessel, and the upper half serves for secondary combustion and differential gravity separation. Flue gas leaves the top and regenerated catalyst is withdrawn from near the bottom. Operating pressure is normally 6 psig at the top and some 11 psig at the bottom. Temperature of the contents is approximately 1100° F.

Since the use of uninsulated carbon steel was obviously precluded by temperature, even though corrosion was not a factor, the choice narrowed to a suitable bare alloy or internally insulated low alloy or carbon steel. Bare alloy, although simple and desirable from the standpoint of low heat storage and consequent quick access for off-stream internal inspection and servicing, had the offsetting factors of field welding problems, probable higher cost, extreme shortage of alloying elements and the possibility of unpredictable localized combustion zones with excessive temperatures which would not be cushioned by insulation. Hence the use of carbon steel protected by internal insulation was elected.

Consideration for Designing Lining

The particularly important considerations for designing the lining were: thermal expansion, cumulative loading, the effect of infiltration of micro-catalyst particles on the thermal conductivity, prevention of catalyst flow behind the insulation with the resultant excessive metal temperatures and possible serious erosion, and resistance to catalyst erosion on the exposed surface. Other items were maximum speed of construction and minimum manpower requirements consistent with satisfactory end results. The three practical possibilities were monolithic installations, the use of fire brick with or without supplementary backing insulation and suspended tile with backing. From the standpoints of cost and manpower, the monolithic appeared most attractive. It was recognized that regardless of the method, a carefully planned and executed field installation and drying technique would be all-important. While Hydroforming unit experience at this time was limited, nevertheless it was an appreciable factor in certain of the designs.

All methods were used in different designs and trouble was experienced in varying degrees. Generally speaking, the suspended tile type has been the most successful, particularly in the larger units, apparently because it provided the best solution to the expansion and cumulative loading problems.[1]

A typical interlocking tile suspended wall installation used in the example vessel is shown on Figure 2. The bottom and top head arrangements are similar and differ only in minor details. The dense high temperature block internal insulation was laid up very compactly in two layers with all joints pointed with

plastic. The refractory tile was pressed into place in a bed of plastic and positioned to maintain carefully calculated expansion openings. Carbon steel "vapor stops" were provided to arrest any tendency for flow of vapor and/or catalyst behind the tile. After more than three years service, the only maintenance has been the repacking of one nozzle opening where the design metal temperature of 735° F. was reached.

The success of this particular installation is attributed to sound fundamental design and unusually rigid inspection of the actual installation work. Although it required a greater expenditure in man-hours and money than the simplest alternative, the judgment in selecting this type is considered well supported by the performance record.

FLUID CATALYST UNIT—Piping

This class of unit presented many and varied piping design problems in fields beyond prior experience. One of the most difficult examples is the line which delivers some 40 tons per minute of aerated spent catalyst from a point approximately at grade to the bottom of the regenerator vessel described in the preceding section and located some 52 feet above grade. The basic conditions to be met: temperature, 950° F. entrance, 1050° F. exit; pressure, 11 psig; corrosion, negligible.

These data alone belie the magnitude of the problem. Additional major factors were the necessity for streamlining the flow to minimize erosion by catalyst, a line diameter of approximately 72 inches, a 90° turn to change direction from horizontal to vertical, appreciable thrust loads, and limited data on the flexibility of bends of thin wall pipe in large diameters, particularly under such conditions of temperature and loading. In other sizes and/or types of units designs have employed carbon-moly pipe, or refractory tile, monolithic and brick insulation, both with and without liners. In this case the use of internally insulated carbon steel pipe appeared the best because of fabrication and erection problems pertinent to carbon-moly steel, the shortage of alloying elements for higher alloys and the advantage of a replaceable liner in case of localized erosion because erosive conditions would be approached in order to keep the line diameter to a minimum. Since the flow of the carbon-bearing catalyst would be effected by the introduction of carrier air, some combustion would take place in the line. Thus internal insulation would reduce any extreme differences in pipe wall metal temperatures that might result from unanticipated peculiarities in the flow or combustion pattern.

The design is shown in Figure 3. Liner expansion was cared for by lap rings with the open ends on the downstream side to minimize catalyst intrusion. Angles located circumferentially provided rigidity and high temperature dense insulating block was placed in the annular space between the liner and pipe wall.

In actual operation, excessive metal temperatures developed gradually and after about a year a leak occurred as indicated in Figure 3. The adjacent lap ring and liner were eroded severely, all insulation had disappeared in the immediate vicinity and some 75 percent was gone from the horizontal section of the line indicating catalyst flow behind the liner. Since erosion of the lap rings was general the liner was welded solidly into 12-foot, 6-inch sections, the remaining lap rings were protected by an upstream buffer strip, a vapor stop was provided in the center of each section and the insulation was replaced with the pumpable type described under the Hydroforming Unit. Since the severest erosion occurred inexplicably on the inside of the bend an aeration or "fluffing" line was installed to prevent possible catalyst pile-up and consequent velocity increase in the horizontal section and lower section of the bend. With the exception of minor corrections such as increasing the lap ring width to assure lapping under all conditions, the modified method has now served quite satisfactorily for more than 2½ years. Erosion has been slight and pipe metal temperatures have remained in normal range of 250-400° F. Results to date indicate that all corrective steps have contributed to a sound design.

It is important to note that the original design proved satisfactory in the vertical section of the line and in numerous other places where conditions were less severe. In other words, a number of contributory factors necessitated the considerable modification in the initial arrangement for this unusually difficult problem.

CONCLUSIONS

The use of internally insulated vessels and piping is a practical and economical solution to the design of certain high temperature equipment. Application requires a full knowledge of the conditions which must be reckoned with and an extremely careful engineering analysis of the fundamental factors pertinent to a given installation. Increased and diversified experience plus a greater selection of materials increases the possibilities in this field. However, let us neither be carried away by the difficulties discussed above nor be unduly tempted—the optimum solution to a given problem may or may not be the use of internal insulation.

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A Change House Ventilation Design For the Gulf Coast

H. E. BOVAY, JR.
Consulting Engineer, Houston

THE Gulf Coast, with its normal high humidity and warm weather, has always presented problems in proper design of ventilation and cooling equipment. Therefore, the problem of designing a change house for Humble Oil & Refining Company at their Baytown, Texas refinery re-opened the question of adequate ventilation and suitable cooling for the Gulf Coast climate.

It was desired to provide 1500 men with lockers, sanitary facilities and showers. These men represent all groups normally found in a large petroleum refinery. Accordingly, it was desired to provide proper ventilation of lockers to prevent odors and to dry clothing which was wet from rain or perspiration. It was also desired to provide a light, airy atmosphere in the locker rooms and to keep them cool enough for comfort of the men using the facilities. Pleasing appearances and surroundings were required, and the cost was to be held to a minimum so that the largest number of men could be served, when the building is constructed.

In addition to the locker facilities a concourse was required to allow the men to check in and out by means of time clocks, and to pay them twice a month. A mezzanine provides office space for time-keepers.

Keeping the cost to a low figure and still providing heating, ventilation and cooling resulted in a decision to eliminate complete air conditioning systems except for the time-keepers' offices where people worked all day.

The office space is to be air conditioned both summer and winter with a standard air conditioning unit and freon compressor with duct work. The return air passes through the conditioned space so only supply duct is required. An induced draft cooling tower is included because its cost is less than connections to existing cooling towers.

The nine pay booths will be in use only two days per month from about 6:30 to 8:30 a. m. and 3:30 to 5:30 p. m. The offices will be occupied from about 7:30 a. m. to 4:30 p. m. Use of the pay booths overlaps the time the offices are occupied only one hour morning and afternoons, two days per month. Provision was made to serve the pay booths with the same air-conditioning system by running a duct of lightweight pipe, suitably protected from soil corrosion under the floor. Due to low soil temperatures this duct is not insulated, and since the pay booths will be served at the expense of the office space (and the load is less) the air-conditioning equipment is sized for the load of the office space.

The concourse is heated by four unit heaters each with a fan delivering approximately 5400 cubic feet per minute and installed so as to obtain a gentle circular motion horizontally around the concourse. The heaters operate on steam at 135 psig saturated. Temperature control is simply a thermostat operating a control valve in the steam supply line and the fan motors are controlled by a switch at the lighting panels.

The concourse is ventilated in warm weather by two 45,000-CFM exhaust fans, manually controlled in the roof. Air is pulled through doorways and discharged through the fans. Approximately one air change every 1.8 minutes will be obtained.

Locker Rooms

All of the foregoing is generally considered good practice and the problems, while interesting, were not difficult. The elimination of odors and adequate ventilation in the locker rooms required more thought and discussion. Information was obtained on similar installations in the area, and a number of persons having experience with similar problems were contacted. Finally, it was decided to provide three floors for locker rooms, the ground floor to start about 4 feet below grade, and each floor to be approximately 11 feet high.

The layout of the building and its ventilation is shown in the schematic cut-away view attached. Outside air enters through louvers set in glass block walls, passes through the spaces around the lockers, then through louvers in the lower part of the locker doors, up through the lockers and into the spaces above the lockers. These spaces are furred in, forming ducts which deliver the air into the plenum chambers over the showers. The air then flows from these chambers to the central plenum chamber which is vertical and which delivers the air into exhaust blowers in the attic, which discharge it into ducts and louvers in the roof. Provision is made for minor quantities of air to pass through sanitary type registers in the ceiling above the showers and water closets, to take away odors and water vapors from these spaces.

Automatic fire dampers are provided for each bank of lockers. These are adjustable, and together with the registers above the shower spaces and the adjustable louvers in the outside walls, give complete control of air quantities. The blowers are to be capable of operation even at full shut-off of air.

The flow of air is thus designed so that it will not be uncomfortable for a man in the shower; some increased velocity (increased cooling effect) occurs in the drying space; and as one goes toward the outside wall, the velocity increases until it is about 38 feet per minute in the outside aisle. This latter figure approaches the peak for satisfactory cooling of persons.

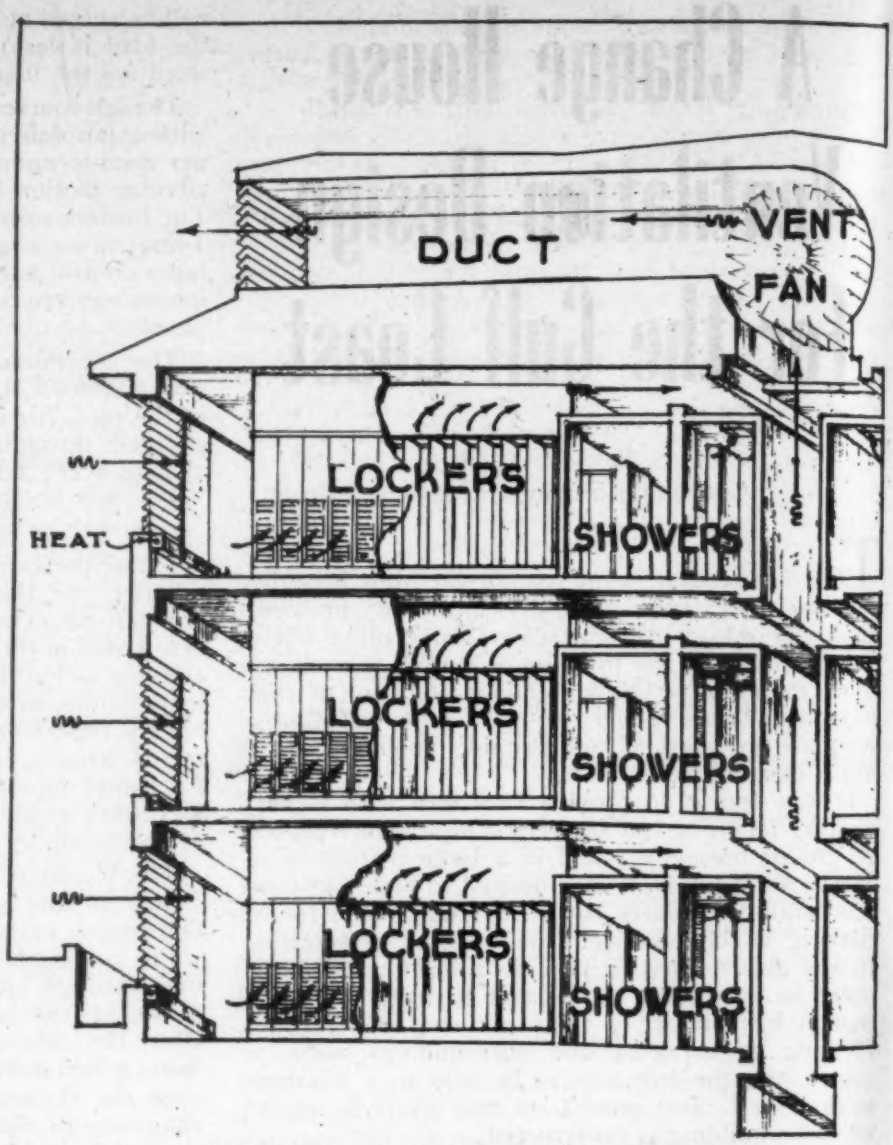
A total of 320,000 CFM of outside air can be pulled through the three rooms by means of four blowers each handling 80,000 CFM. Probably all four blowers will operate during summer at shift change hours. Less than this number will be used in the spring and fall and at times during winter they will all be shut down.

Winter heating will be obtained from convectors

mounted under the louvers in the outside walls and operating on steam at 135 psig saturated. These convectors will be manually controlled. Their cost is estimated at a little more than that of unit heaters, but it was felt that more even distribution of heat and air motion would be obtained and any leakage through the louvers would be less likely to cause cold spots.

Returning to the summer operation, which is of the greatest interest, because of the high humidity and temperatures which prevail, careful thought was given to ventilation of the lockers as well as the cooling effect in the room spaces described above. Thought was given to providing drying spaces, both in separate rooms and above the lockers for wet or damp clothing. This would have required valuable space and would be unsightly. Perhaps additional employes would be required to handle clothes under this plan. The volume of air would probably have been increased to obtain adequate drying. Therefore, it was decided to dry the clothes in the lockers.

Calculations and judgment, together with the cooling requirements finally set the volume of air movement of 320,000 CFM. This results in 1140 air changes per hour through the lockers. It was felt that this would generally provide for ventilation and drying, and while peak loads might not be met, would be economically feasible and in balance with the complete design.



Isometric Cut-away View of Refinery Change House

Test Is Run

While final design and specification work was proceeding on this basis, it was decided to obtain test data based on the foregoing. Humble Oil & Refining Company had a small locker room available for such tests and installed an available blower. The lockers were of the same approximate size (14 inches wide by 18 inches deep by 66½ inches high) as those to be used and contained 64 ½-inch diameter holes in each door. The tops of the lockers were open and shelves near the top were 10 inches wide, with open spaces both back and front of 4 inches.

Velocity was regulated with a damper in the air duct and measured with an anemometer located in the duct. A thermometer and sling psychrometer were used to obtain temperatures and relative humidity data. A number of tests were made and the rate of changes tested were 60, 80, 120, 320, 730, and 1000 per hour. At the start of each test clothing (coveralls) was immersed in water then wrung out by hand and hung in the center of each locker. Air was circulated until clothing was dry.

The average relative humidity varied from 65 to 82 percent and the temperature from 78 to 82° F. At higher humidity and low rate of air change as much as 94 hours were required to dry the wet clothing completely, but odors were not apparent from lockers thus ventilated. Odors were apparent from lockers which had not had air circulation. The air change of 1000 per hour occurred at 82 percent average relative humidity and 82° F. dry bulb. It was raining during the test. Wet coveralls were placed in one locker and damp coveralls in a second locker. Sixteen hours were required to dry the damp coveralls and 24 hours to dry the wet coveralls.

Thus it can be seen that rates of air change of less than 1000 per hour would probably eliminate odors but would not dry clothing in a reasonable period of time when high humidity conditions so prevalent on the Gulf Coast exist. On the other hand, it appears that rates of 1000 air changes per hour or greater will be satisfactory practically all of the time, and that these rates can be obtained economically.

ACKNOWLEDGMENTS

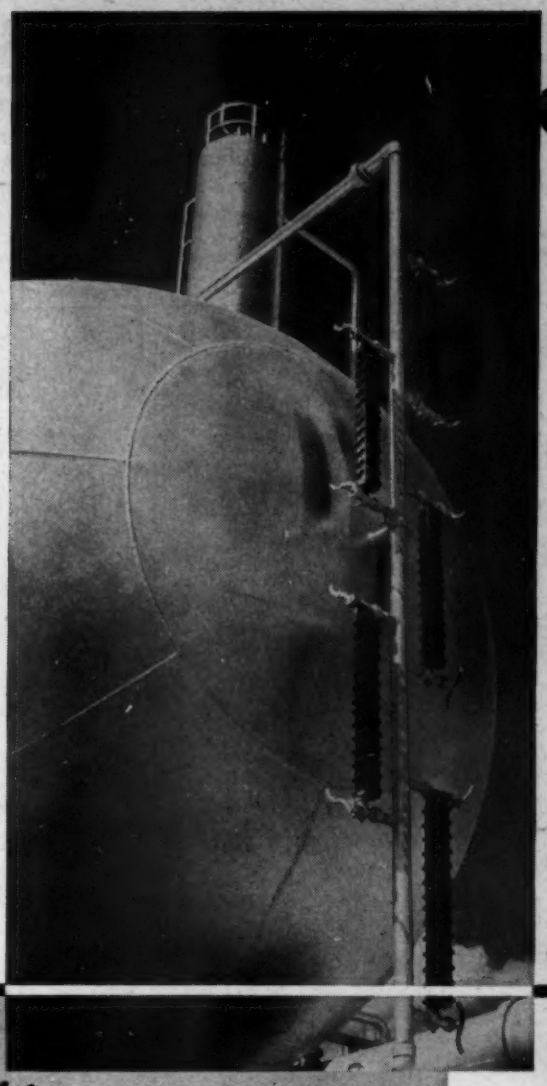
The building discussed was designed for Humble Oil & Refining Company by Stayton Nunn-Milton McGinty, architects, and the writer served as consultant for design of mechanical work. E. H. Busby was Humble's project engineer. The above tests were made by P. L. LaFosse of Humble's maintenance engineering and inspection department.

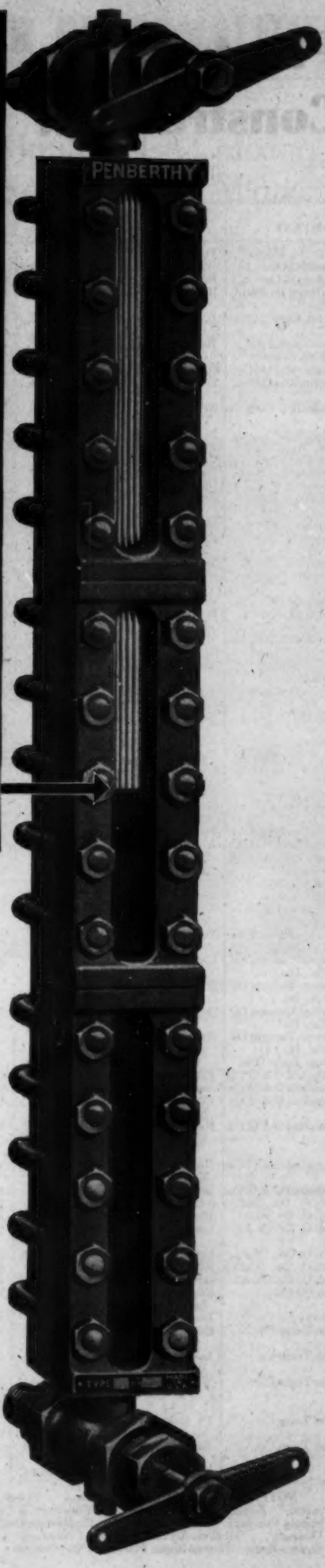
WHEN YOU MUST

BE SURE

OF THE

LIQUID LEVEL





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Plant Construction

Petroleum Refiner again presents a "box score" of refinery and plant construction work that is under way or projected at the present time. A number of revisions, additions, etc., were made following its first appearance in the September issue.

No claim is made as to the completeness of the tabulation, but it is hoped that with the cooperation of all companies involved it will become more complete with successive publications. Companies are asked to: 1) send in data on units not listed; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
Agwi Pet. Corp.	Fawley, Eng.		120,000 bbls.	$140 million	Projected	1952			
Barcco Oil Co.	Wichita, Kans.	Cat desul. & Ref.	7,500 bbls.	$500,000	Under Constr.	Early '48	Phillips	Koch Eng. Co.	Koch Eng. Co.
Carter Oil Co.	Billings, Mont.	Crude cat crk.	20,000 bbls.	$20 million	Under Constr.	1948		U.O.P.	Fluor Corp.
Carthage Hydrocol, Inc.	Brownsville, Tex.	Synthine	64,000 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc., Texaco Dev. Co.		McKee
Citcon Corp.	L. Charles, La.	Lube Plant	6,000 bbls.	$30 million					
Consolidated Ref. Ltd., Consol.	Haifa, Palestine	Crude Plant	124,000 bbls.			By 1950	Lummus Co., Kellogg	Lummus Co.	Lummus Co., Max B. Miller Badger
Continental Oil Co.	Billings, Mont.	Cat cracking	7,500 bbls.	$8.5 million	Contract signed	1949	U.O.P.	U.O.P.	
Continental Oil Co.	Denver, Colo.	Crude, cat Crk.	7,500 bbls.	$4 million	Under constr.	Fall 1948	Houdry Corp. & U.O.P	Con. Oil Co.	J & L Supply Lummus Co.
Creole Pet. Corp.	Amuay Bay, Venezuela	Cat cracking	60,000 bbls.	$70 million	Under constr.	1950			
Ethyl Corp.	Baton Rouge, La.	Mann. facilities		$20 million	Announcement				
Gray-Wolfe Co.	Montgomery Co.	Gasoline plant	13,000 mcf	$2 million	Under constr.	Jan. 1949			
Gulf Oil Corp.	Crane Co., Tex.	Gasoline plant	23,000 mcf					O. L. Olsen	O. L. Olsen
Humble O & R Co.	Baytown Tex.	Lube plant		$5 million	Projected				
Humble O & R Co.	East Texas	Gasoline plant		$2 million	Under constr.				
Humble O & R Co.	Katy, Texas	Propane, Butane Extraction	19,000 bbls.	$7 million	Contract let			Fish Eng. Corp.	
Humble O & R Co.	Refugio, Tex.	Gasoline plant		$2.5 million	Under Constr.	1948			Stearns-Roger
Kanotex Refg. Co.	Arkansas City, Kans.	Cat Cracking			Contract let	Early '48	Phillips		Gaso. Plant. Koch Eng. Co.
Lion Oil Co.	El Dorado, Ark.	Cat Cracking	4,500 bbls.	$2.5 million		Comp. 9-12-47	Houdry Corp.	Lummus Co.	Lummus Co.
Fred M. Manning, Inc.	Stephens Co., Texas	Pres. Main.	20,000 mcf	$500,000	Contract let	Jan. '48		Fish Eng. Corp.	
Magnolia Pet. Co.	Beaumont, Tex.	Lube plant	90,000 mcf		Under Constr.	Jan. 1, '49			
Magnolia Pet. Co.	Seeligson Field, Texas.	Gasoline plant	90,000 mcf			Late '48		Hudson	
McCarthy Chem. Co.	Winnie, Tex.	Petro-chem, Cat ref.	5,000 bbls.	$3 million	Under constr.		Phillips	Fish Eng. Corp.	
Mid-Continent Pet. Corp.	Tulsa, Okla.	Vac still, cat cracking	45,000 bbls.	$8.5 million	Contract let	June '48	Kellogg	Kellogg	Kellogg
Monsanto Chem. Co.	Texas City, Tex.	Rebuilding Petro-chem.		$6 million	Contract let				Bellows Co., Leo Con. Co.
Ohio Oil Co.	Robinson, Ill.	Vac unit, cat cracking	27,500 bbls.	$15 million	Under Constr.	Late '48	U.O.P.	McKee	McKee, Pritchard
Plomo Co.	Nuedes Co., Tex.	Gasoline plant			Awaiting Appr'l				
Porto Marghera R.	Venice, Italy	Enlarging							
Pure Oil Co.	Smith's Bluff, Texas	Lube plant		10 milliom	Contract let				
Shell Chemical Co.	Thornton, Eng.	Petro-chem.		Several million	Under constr.				
Shell Chemical Co.	Shell Haven, Eng.	Petro-chem.							
Shell Chemical Co.	Stanlow, Eng.	Petro-chem.							
Shell Chemical Co.	Houston, Tex.	Glycol		Part $25 mln.	Under constr.	Early '48			
Shell Chemical Co.	Shell Pt. Calif.	Syn. Ammonia				Early '48			Kellog
Shell Oil Co.	Notrees, Tex.	Gasoline plant	40,000 mcf		Under constr.	Early '48			
Shell Oil Co.	Houston Tex.	Lube unit		$10 million	Constr. approved				
Shell Oil Co.	Denver C., Tex.	Gasoline plant	24,000 mcf		Under constr.	1948			
Richardson & Bass	Keystone Field, Texas	Gasoline plant	70,000 mcf		Constr. approved	10-1-48			Fluor Corp.
Socony-Vacuum Oil Co., Inc.	Paulboro, N. J.	Lube plant			Under constr.	Jan. 1, 1949		J & L Supply	J & L Supply
Socony-Vacuum Oil Co., Inc.	Casper, Wyo.	Cat cracking	5,000		Under constr.	Jan. 1, 1949			
Socony-Vacuum Oil Co., Inc.	E. St. Louis, Ill.	Delayed coker & distillation				Jan. 1, 1949			
Socony-Vacuum Oil Co., Inc.	Augusta, Kans.	Cat cracking	10,000			Jan. 1, 1949			Cat. Constr. Co.
Socony-Vacuum Oil Co., Inc. White Eagle Div.	Augusta, Kans.	Cat cracking				Early '48			
Stanolind O & G Co.	Elk Basin, Wyo.	Gasoline plant	12,000 mcf		Approved			Stone & Webster	Stone & Webster
Stanolind O & G Co.	Slaughter, Tex.	Gasoline plant	90,000 mcf		Approved			C. F. Braun	C. F. Braun
Stanolind O & G Co.	Hugoton Field, Kans.	Gasoline plant	150,000 mcf		Approved			J & L Supply	J & L Supply
Stanolind O & G Co.	Hugoton Field, Kans.	Gas syn plant	100,000 mcf		Announced			Kellogg, Foster Wheeler, Stone & Webster	Kellogg
Stanolind O & G Co.	Hugoton Field, Kans.	Chem. plant	130,000 lbs./yr.		Announced			Badger	Badger
Stanolind O & G Co.	Brownsville, Tex.	Chem. plant	130,000 lbs./yr.		Announced				
Std. O. Co. (Ind.)	Sugar Crk., Mo.	Cat cracking	25,000 bbls.			Early '48		Badger	Badger
Std. O. Co. (Ind.)	Whiting, Ind.	Cat cracking	25,000 bbls.			Early '48			Kellogg
Std. O. Co. (N.J.)	Linden, N.J.	Vac, cat cracking, pipe still	90,000 bbls.		Contract let	1949			Kellogg C. F. Braun
Std. O. Co., (N.J.)	Baton Rouge, La.	Vac. still, crude	96,000 bbls.		Projected				
Std. O. Co., (Calif.)	Richmond, Calif.	Grease	82,000 lbs.	$5.2 million	Under constr.	Sept. '48	U.O.P.	W. G. Peugh	Barrett & Hilp
Std. O. Co. (Ohio)	Lima, Ohio	Cat cracking	6,000 bbls.	$10 million	Contract let	Late '49	U.O.P.	McKee	McKee
Sun Oil Co.	Richland Parish, La.	Gasoline plant	70,000 gal.		Under constr.				Pet. Eng., Inc.
Sunray Oil Co.	Duncan, Okla.	Crude plant	20,000 bbls.		Under constr.	Late '47			
The Texas Co.	Eagle Pt., N.J.	Vac. still, cat cracking	40,000 bbls.		Contract let	Late '49		U.O.P.	
The Texas Co.	Lawrenceville, Ill.	Crude and cat cracking	20,000 bbls.		Announced	1950		Kellogg, Texaco Co.	Kellogg, Foster Wheeler
The Texas Co.	W. Tulsa, Okla.	Crude a cat cracking	30,000 bbls.		Contract let	1949		Foster Wheeler	Kellogg, Foster Wheeler
The Texas Co.	Pt. Arthur, Tex.	Lube addition	2,000 bbls.		Under Constr.	Late '48		Texas Co, Kellogg, Foster Wheeler	Kellogg, Foster Wheeler
The Texas Co.	Casper, Wyo.	Cat Poly Naphtha reformer, pressure coker	10,000 bbls.		Completed		Kellogg	Texas Co., Foster Wheeler Kellogg	Foster Wheeler Kellogg

NOTE: Badger—E. B. Badger and Sons. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat Constr.—Catalytic Construction Company. Fluor—Fluor Corporation. Gaso. Plants—Gasoline Plant Construction Company. Houdry—Houdry Corporation. Hudson—Hudson Engineering Corporation. J & L Supply—Jones Laughlin Supply Company. Koch Eng—Koch Engineering Company. Kellogg—M. W. Kellogg Company. Leon Constr.—Leonard Construction Company. Lummus—The Lummus Company. McKee—Arthur G. McKee Company. Phillips—Phillips Petroleum Comapny. Pet. Eng.—Petroleum Engineers, Inc. Pritchard—J. F. Pritchard & Company. Stearns-Roger—Stearns-Roger Manufacturing Comapny.

REFINER AUTHORS . . . . . and OTHER PERSONALITIES

Mass Spectrometer Author a Gardener

"THE Mass Spectrometer and the Control Laboratory" comes from the pen of Daniel Milsom, laboratory supervisor, Cities Service Refining Corporation, Tutwiler Refinery, Lake Charles, La. The author assisted in the installation of the mass spectrometer at Cities Service and trained the present group of operators. Inasmuch as this was a refinery laboratory, a minimum of time was spent on research and development, it being Milsom's chief aim to install and calibrate the instrument for routine analysis as outlined in his article. See page 83.

DANIEL MILSOM

A graduate of Pennsylvania State College, Milsom has had nine years experience in industrial and research laboratories. His chief interests, not necessarily in the order of their importance: electronics, amateur radio, three children, gardening, and photography. His friends say that he works with the same zeal and energy at his hobbies as he does at his profession as a spectrographic analyst.

Help on Refiner Figures from Nearby

WORLD OIL (formerly The Oil Weekly) and PETROLEUM REFINER are sometimes referred to as "sister publications" inasmuch as both come from Gulf Publishing Company, Houston. Well, in the L. J. Logan article dealing with current refining capacity and outlook (page 89) we have a brother editorial man from a sister publication turning up with a worthwhile contribution.

Logan, associate editor of *World Oil*, is a journalism graduate of the University of Texas (also did graduate work there) who has been with *World Oil* (established in 1916 as The Oil Weekly) since 1927. In recent years he has been specializing in articles of an economic nature. This usually involves some statistics. He's recognized throughout the oil industry as "having something on the ball."

Papers From Three ASME Members

THREE articles in this month's PETROLEUM REFINER were presented at the Petroleum Division of the 1947 Conference on Petroleum Mechanical Engineering, of the American Society of Mechanical Engineers, held early this month in Houston.

The author of "Internally Insulated Piping and Pressure Vessels," page 129, is **P. E. Darling,** chief refinery engineer of Pan American Refining Corporation, Texas City, Texas. Darling obtained his bachelor's degree in Chemical Engineering at Massachusetts Institute of Technology in 1927 and then became associated with American Smelting and Refining Company in Mexico and the United States. After subsequent connections with Brown Instrument Company and Magnolia Petroleum Company he joined Pan American in 1934. He is a member of the executive committee of the South Texas Section of ASME and is quite active in civic affairs in his home town.

Charles S. Pugsley, Jr., a Missourian by birth but a Texan by education (San Benito public schools, Brownsville Junior College, University of Texas B.S. in Mechanical Engineering, 1937) has contributed the "History of Some Austenitic Furnace Tubes" (starts on page 119). He has been with Standard Oil Company of New Jersey, Louisiana Division, Baton Rouge, since June, 1937. Here he has advanced from junior mechanical engineer to assistant head of the equipment inspection department which post he has held since January of this year. He is married and has three children.

Finally in the ASME triumvirate is **Arthur M. Whistler,** author of the article on page 114, "Effect of Leakage Around Cross Baffles in a Heat Exchanger." Four years after Whistler obtained a 1922 degree of B.S. in Physics and Engineering from the California Institute of Technology, he entered the employ of C. F. Braun & Company, Alhambra, Calif. And he's still with them, now as consultant for process and supervisor of research. His work has covered engineering of multi-component fractionation, heat exchange, bubble columns as well as research on these items. He also served as project engineer for a number of jobs, these including absorption plants, fractionating units, a thermal cracker, a Fluid cat cracker and a number of special units.

Hunting Isn't Mixing So Well With Work

"A CHANGE House Ventilation Design for the Gulf Coast" (starting on page 135) is authorized by H. E. Bovay, Jr., of Houston, who now for nearly two years has been in private practice as consulting engineer, his work including plant studies, construction planning, supervision of engineering design, selection of equipment for additions to small refineries, natural gasoline plants, chemical plants, etc. His clients include some of the nation's largest firms.

H. E. BOVAY, JR.

Bovay, son of Harry E. Bovay of Memphis, Tenn., widely known in the Mississippi Valley as a bridge builder and founder of aviation and industrial enterprises, was graduated from Cornell in 1936 with a C.E. degree. He was in bridge and waterway work himself for a period before joining Humble Oil & Refining Company, Baytown, where he did mechanical engineer work for eight years. One year (1943) he spent as senior materials analyst with PAW in Washington.

In reference to the heading over this article, Bovay's hobbies are swimming and hunting, "neither of which I have had much time for lately because of the requirements of my work and the travel entailed," he admits.

Award to Hook

The American Society for Metals has announced that Charles R. Hook has been elected to receive the Society's Medal for the Advancement of Research for 1947. Hook is president of the American Rolling Mill Company, Middletown, Ohio.

McKee has the organization, the experience and the technical skills to provide progressive design, engineering and construction services for a progressive industry.
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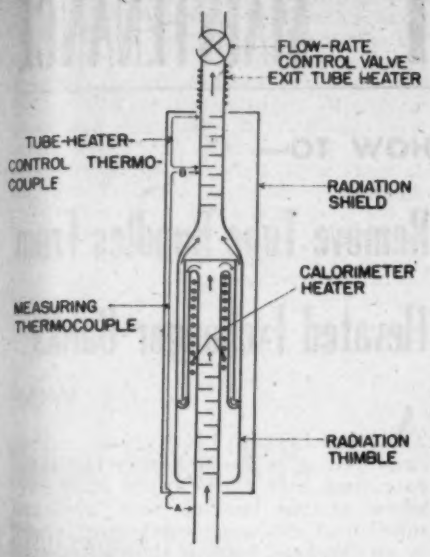
New Flow Calorimeter



A new flow calorimeter for more accurate measurements of the specific heats of gases has been developed by R. B. Scott of the National Bureau of Standards. This apparatus was constructed in connection with a program sponsored jointly by the Bureau and the Office of Rubber Reserve for the determination of the thermodynamic properties of materials involved in the production of synthetic rubber and related substances. The greater precision of the new instrument is chiefly due to the almost complete elimination of heat leaks by various features of design. The small heat capacity of the calorimeter also results in improved accuracy through the easier and more rapid attainment of a constant temperature distribution within the system, since only under conditions of steady temperature is an accurate measurement possible.

The gas under study flows continuously at a constant rate through an insulated compartment, where it is heated electrically, and the specific heat is computed from heat input, temperature rise of the gas, and rate of flow. Entering the calorimeter at the bottom, the gas flows upward through the central calorimeter tube of monel metal past a series of baffles, that act as radiation shields and also promote thermal equilibrium between the gas and the tube walls. In the central part of the calorimeter the gas traverses a labyrinth about the calorimeter heater while its temperature is being raised. The labyrinth is designed to provide an isothermal exterior surface on this part of the calorimeter. The metal radiation thimble extends this isothermal surface to a point very near to where the tube enters the copper radiation shield. Heat exchange by radiation is prevented by heating the shield to the temperature of the inner calorimeter wall with an electric heater, adjusted manually according to thermocouple readings. The rise in temperature of the gas is indicated by the measuring thermocouple. After its temperature has been raised, the gas passes upward again past a series of baffles and out through the flow-rate control valve. The exit tube heater serves to establish a zero temperature gradient in the upper part of the tube, thus reducing heat transfer along the tube. The entire apparatus, except for the flow-rate control valve, is enclosed in a highly evacuated metal case (not shown) immersed in a constant-temperature bath. Before entering the calorimeter, the gas flows through a helical coil, in which it is brought to the temperature of the bath.

AIRETOOL'S NEW FORM* CUTTERS

...guarantees FASTER, MORE EFFICIENT TUBE CLEANING!

Shown above is the single expansion P-type cutter head with 3 cylinder cutters to the row. This same head is also furnished with two or four cylinder cutters, depending upon the coke condition. *This is only one of many types of Airetool cutter heads.* Single expansion, double expansion and wing-arm types are available to meet every refinery tube cleaning problem.

RECOMMENDED FOR STRAIGHT TUBES 2 1/4" to 4 3/4" I. D.

All of the cutters employed in Airetool cutter heads are of the *New Form* type which are proven to be *Absolutely Non-Tracking* . . . even after repeated cleaning operations.

AIRETOOL
MANUFACTURING COMPANY
316 S. Center St.
SPRINGFIELD, OHIO

WRITE FOR BULLETINS ON ALL TYPES OF AIRETOOL REFINERY CLEANERS, EXPANDERS, AND ACCESSORIES.

OPERATION HOW TO DO IT MAINTENANCE

Condenser and accumulator drums elevation.

HOW TO—

Elevate Condensers And Accumulator Drums

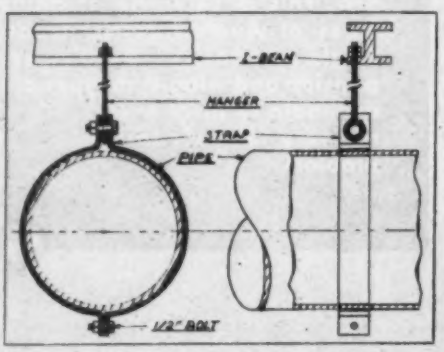
THE trend of design and construction in gasoline plants toward compactness and accessibility of equipment is aided by the use of simple elevated structures as pictured herewith. In this plant individual steel structures are provided for each tower. The platform is large enough to permit the tube bundles to be removed, either by block and tackle or dollys, and with ample room for safe working conditions for the maintenance crew. The accumulator drum for the tower is mounted in the substructure below the platform on the cross-members.

Use of such structures increases the compactness of the plant, reduces the amount of piping involved, provides more ground space, and permits gravity flow from the condensers to the accumulators, and maintains the correct suction head on the pumps, which are on the ground level.

HOW TO—

Simplify Problem of Pipe Suspensions

THE method of suspending pipelines in gasoline plant construction as shown in the accompanying sketch, is somewhat simpler than the conventional methods employed for older plants. As a result of the use of the suspension, construction was speeded by reducing the time required for installation of each suspension, and less skilled labor was required due to the simplicity of the method. The suspension consists of two pieces of strap iron bolted together at the bottom and top to form a clamp on the pipe. An eye-bolt hanger is used to suspend the clamp from the I-beam cross-member of the overhead pipe rack frame. Expansion movement of the pipe is permitted by the eye-bolt hanger, and to reduce the strain due to greater than average expansion movement, the length of the eye-bolt hanger is increased.



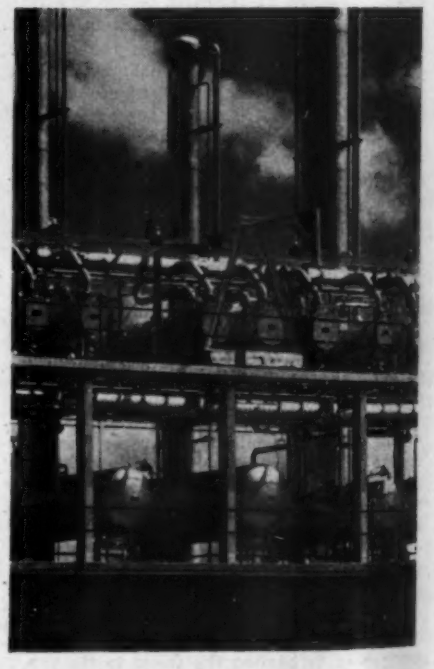
Simplification of pipe suspension.

HOW TO—

Remove Tube Bundles From Elevated Exchanger Banks

AN ILLUSTRATION of the method employed in a gasoline plant to eliminate time and work losses in the removal of tube bundles from "shell and tube" heat exchange equipment located in an overhead bank is shown herewith.

Essentially the system consists of a travelling crane so designed that it can be readily positioned in front of any of the 17 condensers of the bank, to allow a particular tube bundle to be pulled from its shell, inspected and lowered to grade level or returned to service as may be desired. The travelling crane involves a cantilevered I-beam mounted



Trolley hoist for condenser bank.

on a wheeled A-frame. The I-beam carries two trolleys which are each fitted with chain hoists. Main support beam for the travelling crane is located at platform level on the edge of the structure in front of the channel ends of the condensers and runs the length of the condenser bank, carrying a standard track rail on which the crane rides. A secondary guide beam is located immediately above the condenser channels, ends and also runs the length of the condenser bank. This beam serves to anchor the inboard end of the travelling

crane cantilever and takes the reactions imposed by loads on the chain hoists.

In use the chain hoists serve to support front and rear ends of a tube bundle, respectively, with the bundles being pulled from their shells through the triangular "A frame" of the crane and lowered to grade from the outboard end of the cantilever beam. Minor repairs can be made at platform level when desired or the bundles can be removed for major work at a shop or for substitution of replacement bundles.

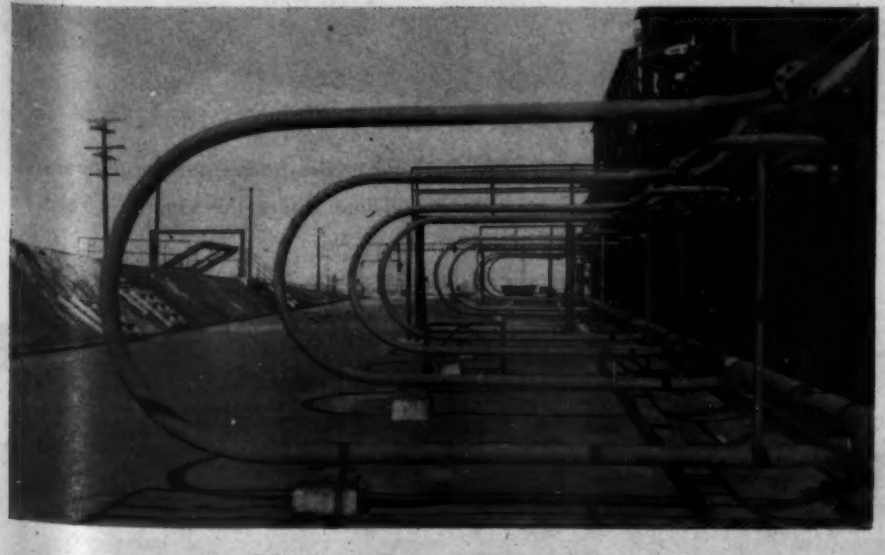
The travelling crane was designed to be placed in immediate service without setting up temporary scaffolding whenever repairs to a condenser are necessary and is part of the original equipment of the plant.

HOW TO—

Relieve Stress With Blowdown Lines

STRESS can be relieved for lines on a series of processing furnaces by installing fabricated pipe loops from the blowdown valve to a common header which carries the material to the blowdown accumulator and vent stack. The lines lead from the furnaces at a tangent, and enter the common header in a like manner. Between these two connections is a long loop of pipe supported on a concrete pier with shoes and guides to control the direction of pipe movement when the temperature changes rapidly as the hot material flows from the furnace tubes. The bearing shoe is a portion of the web and flange of structural steel which rests on a pad of flat metal attached to the top of the concrete pier. Sections of angle iron are placed on either side of the shoe, securely fastened to the shoe plate to guide the loop as it expands. Warping and side-to-side movement are thus prevented.

Compensation shoes for blowdown lines support.



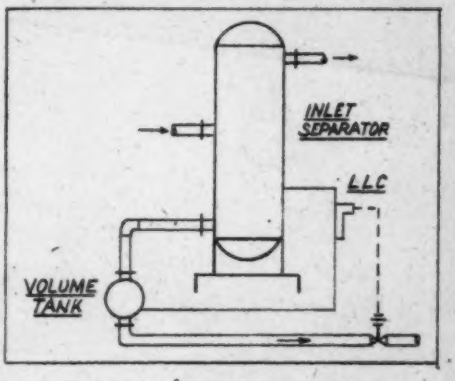
Efficient installation of blowdown lines.

HOW TO—

Increase Plant's Separator Volume

WHEN the intake gas volume to a small cycling plant was increased, it was found that liquid carry-over was occurring at the inlet gas separator. Unable to obtain a second separator for immediate installation, the operator adopted the method illustrated in the sketch to increase the liquid volume of the separator and thus prevent the carry-over.

A 10-foot section of 10-inch i.d. pipe was used as a volume tank and placed below the level of the bottom of the separator. The bottom connection of the liquid level controller was connected to the volume tank and operation adjusted to keep the liquid out of the separator, eliminating entrainment in the gas. The "dry" separator operated satisfactorily.



How to increase separator volume.

HOW TO—

Eliminate Numerous Battery Systems

A TWO-WHEELED battery cart which carries four batteries solves the problem of starting independent multi-cylinder gas engines. The cart is easily moved from one engine to another and eliminates the necessity of having several battery systems on the engines. When not in use the batteries can be stored out of the way and can be kept charged during the time they are not in use.

Handy two-wheel battery cart.

HOW TO—

Distinguish Different Fire Extinguishers

THE Pyrene Manufacturing Company of Newark, N. J., has adopted a color scheme to distinguish different types of fire extinguishers. These colors have been selected to provide strong contrast for instant, positive identification to save precious seconds when a fire starts. There have been cases of fires being spread when an excited workman used the wrong type of extinguisher. Pyrene hopes that these colors will become standard for all extinguishers. Here are the colors:

Bright Blue—Soda-acid and cartridge-operated water-type. For Class A fires (wood, paper, textiles and other ordinary combustibles) in location not subject to freezing.

Bright Red—Foam. All types of foam

NEW! REVOLUTIONARY!

Two Cooper-Bessemer 10-cylinder pumps in operation on a crude oil line where the utmost in reliability is essential.

TWIN LINE Liquid Pumps

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Houston, Dallas, Greggton.

Announcing

Twin-Line LIQUID PUMPS

by Cooper-Bessemer

After five full years of development and intensive testing, Cooper-Bessemer Twin-Line liquid pumps are now available for all services where liquid is to be pumped against high pressures. Fully proved, these heavy-duty units are truly revolutionary — in construction . . . in housing and maintenance economy . . . and in low overall operating cost!

Built in 2, 4, 6, 8 and 10 cylinder sizes, Cooper-Bessemer Twin-Line pumps are designed for capacities from 2400 to 50,000 barrels a day at discharge pressures from 500 to 2000 psi.

Here are only a few of the major advantages they offer you:

1. Tremendous weight and space savings compared with all other reciprocating pumps of equivalent capacity!

2. A normal operating speed of 400 rpm, permitting the simplicity and economy of a direct-connected engine drive!

3. Sensational savings afforded by mechanical efficiencies exceeding 92%, and volumetric efficiencies from 93 to 96%!

4. Extremely wide capacity range through the use of variable plunger sizes and changes of engine speed!

5. Removal and replacement of any single pump cylinder without disturbing the other cylinders!

6. Unequaled accessibility of all liquid end parts requiring maintenance!

These important advantages and many others are explained fully in our new Twin-Line liquid pump bulletin. Why not send now for your copy. Or, get in touch with our nearest office for engineering data on how these revolutionary pumps will fit into your particular plans.

by Cooper-Bessemer

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

Pampa and Odessa, Texas Seattle, Wash. Tulsa Shreveport St. Louis Los Angeles Caracas, Venezuela

extinguishers and foam making equipment. For Class A and Class B (gasoline, oil, lacquers and other flammable liquids) fires.

Dark Green—Pump tanks and cartridge-operated anti-freeze extinguishers. For Class A fires in locations subject to freezing.

Reddish Brown—Vaporizing liquid. For Class B, Class C (electrical equipment and wiring, calling for a non-conducting extinguishing agent) and small Class A fires.

HOW TO—

Safely Open Valves In Fire Area

WITHOUT a doubt any effort toward making and improving the safety of a refinery is a worthwhile and necessary phase of plant operation. The Shamrock Oil and Gas Corporation at its McKee refinery, Sunray, Texas has a system by which it is possible to open the drop-out lines on the pressure vessels, should a fire occur in the process area.

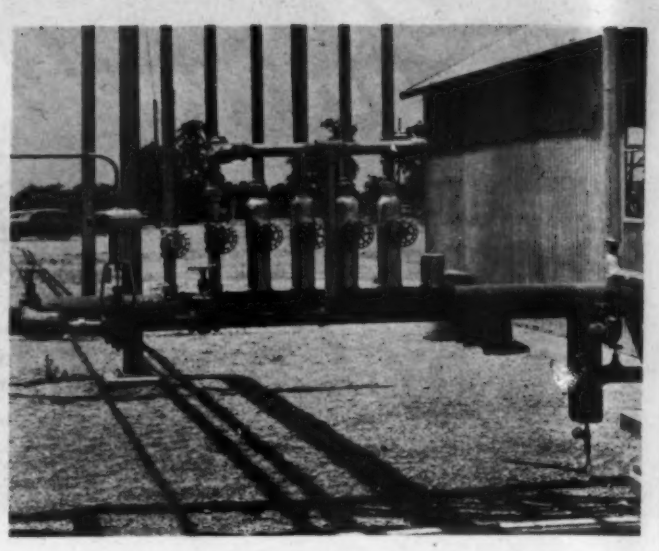
These two pictures show working parts of the scheme used by Shamrock in its McKee refinery for opening the drop-out lines on the pressure vessels, should a fire occur in the process area. Above is the cable terminal, located a safe distance from the process area. Below is the cable wheel on drop-out line of pressure vessel.

By mounting to the valve plug a grooved wheel around which a cable is wrapped and extending the cable to a safe area, simply pulling the cable opens the valve, allowing the liquid in the tower to run out in the blow-down pit, thus eliminating the feed to the fire.

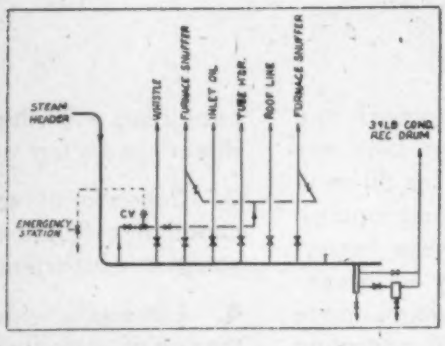
A central terminal where cables from several vessels terminate, facilitates quick dumping of the vessels. Cables run to the terminal in separate conduits. At each bend of the conduit, wheels are mounted in the elbows to prevent binding. At the terminal each cable is labeled to eliminate any doubt as to which valve is to be opened. This type of device is adaptable on gate valves, globe valves or stop-cocks.

HOW TO—

Safeguard Rich Oil Heaters in Cycling Plant



At right, photograph of furnace snuffer manifold. Sketch below shows general plan of such a hook-up.



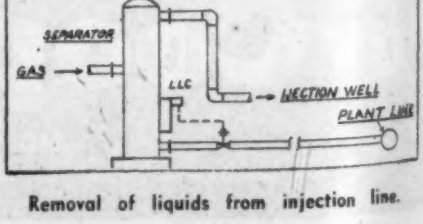
ONE method in use for safeguarding rich oil heaters in cycling plants is illustrated in the accompanying drawing and photograph. One of the interesting features of the system is the method of utilizing the emergency shutdown system of the plant, so that the system can be operated manually or automatically with the rest of the plant emergency system.

The system consists simply of a steam header to which five lines from the heater are manifolded. The accessibility and location of the manifold permits the operator to turn live steam into the inlet oil stream, the tube header, and the roof line. The two snuffing lines assure that sufficient steam is turned into the heater to snuff out fires and prevent them from spreading. A steam whistle is provided so the operator can give the alarm at the same time he operates the snuffing system.

HOW TO—

Remove Liquids From Injection Line

CONDENSATION of liquids due to pressure drop expansion in an extremely long field injection line, which ran down grade for several miles of its length, led to installation of the separator shown in the accompanying diagram. The injection line ran parallel to the gas production line to the plant, so that by placing a separator in the injection line equipped with a liquid level controller, the liquids were collected and pressured through a connecting line to the inlet gas line to the plant. Use of the separator prevented freezing of the line and plugging of the formations in the injection well.



Removal of liquids from injection line.

Consolidated's Haifa Refinery Expansion Stepped Up to 150,000 Barrels Daily

Complete revision of plans have just been decided on for the expansion of the Haifa, Palestine, plant of Consolidated Refineries, Ltd., by which the refinery capacity will be stepped up to 150,000 barrels daily and the previously projected program for a 5000-barrel a day lubricating oil plant will be reduced to 2500 barrels a day. The drastic change in the refinery's over-all plan as announced earlier this year is understood to be dictated by both political and economic factors, the most important reason being the need for larger volumes of product for the Eastern Mediterranean area. Consolidated Refineries is owned jointly by Anglo-Iranian Oil Company and Anglo-Saxon Petroleum Company (Shell) and went on stream after the outbreak of the war in 1939.

The expansion program now being detailed calls for installation of a fourth crude unit of 80,000 barrels daily to supplement the other three of 26,000 barrel capacity each. The new unit is on order from E. B. Badger & Sons of Boston. The enlargement program will be completed by 1950 at about the time the new 16-inch Iraq Petroleum Company pipe line opens from the Kirkuk fields to Haifa and to Tripoli, Lebanon. It is understood that the recent decision to boost the Haifa plant's capacity from the originally scheduled 105,000 barrels a day to 150,000 barrels a day is in anticipation of larger tenders from the IPC line when it goes into operation.

Grades of Products Unchanged

The new lubricating oil division of the refinery will produce 2500 barrels a day of finished products of various grades. This part of the plant will consist of one vacuum-distillation unit with capacity of 12,000 barrels daily of residue from crude stills; one propane-deasphalting unit designed by M. W. Kellogg Company; one furfural-extraction; one M.E.K.-dewaxing unit and one clay-contacting unit. The Lummus Company is designing the last three. Earlier this year Consolidated had planned to install two of each of the above units, and the revised program cuts installation to one each but does not change grades of finished product.

In addition two SO_2 extraction plants are to be installed in connection with facilities for production of about 15,000 barrels daily of high-grade kerosine. Also expanded offices, laboratory and workshops are projected.

The refinery's power plant will be expanded by the addition of two more generators of 6000 kw hour each and by installation of three new 150,000-pounds-per-hour steam boilers. Two more cooling towers, 250 feet high and of 250 feet base diameter, of the parabolic type, will be erected. Each of these towers, a product of Film Cooling Towers, Ltd., England, can cool 2 million gallons of water per hour.

One additional water line will be laid to wells six miles north of the refinery.

Total cost of the expansion program has not been disclosed, but it is said that the newly revised plans will not reduce costs over the plan previously adopted. The original refinery cost was around $20 million, and the expansion work will run more than that figure.

The refinery was designed by Kellogg and work on it was rushed with the outbreak of the war. The first two crude distillation units were completed late in 1941, supplementing the topping unit, three treatment units, acid plant, acid-tar unit which were then in operation. Work was completed in 1943, but some extensions were made in 1944. The refinery was bombed repeatedly during the war by Italian fliers, but damage was slight.

Meetings

October

15-18—Electrochemical Society Fall Congress, Copley-Plaza Hotel, Boston.
16-18—National Lubricating Grease Institute, annual meeting, Edgewater Beach Hotel, Chicago.
20-24—Annual Meeting, American Society for Metals, Palmer House, Chicago.
18-24—American Society for Metals Exposition, International Ampitheater, Chicago.
20-22—American Society of Mechanical Engineers, Fuels Division, Cincinnati.
20-24—Annual Meeting, American Welding Society, Sherman Hotel, Chicago.
21-25—Pacific Chemical Exposition, San Francisco, Civic Auditorium.
23-24—American Institute of Mining & Metallurgical Engineers, Petroleum Division, Fall Meeting, Los Angeles, Elks Club.

November

6- 7—Society of Automotive Engineers, fuels and lubricants meeting, Hotel Mayo, Tulsa.
9-12—American Institute of Chemical Engineers, annual meeting, Statler Hotel, Detroit.
10-13—American Petroleum Institute, annual meeting, Stevens Hotel, Chicago.

December

1- 5—American Society of Mechanical Engineers, annual meeting, Atlantic City, N. J., Chalfonte-Hadden Hotel.
1- 6—21st Exposition of Chemical Industries, Grand Central Palace, New York.
12-13—American Chemical Society, Southwest Region, Houston.
29-30—Fourteenth Annual Chemical Symposium, American Chemical Society, Chicago.

March

24-26—Natural Gasoline Association of America, annual convention, Fort Worth, Texas Hotel.

April

5- 7—Western Petroleum Refiners Association, annual meeting, Galveston, Galvez and Buccaneer Hotels.
19-21—American Society of Lubrication Engineers, annual convention, Buffalo, Statler Hotel.
21-23—National Petroleum Association, Cleveland, Hotel Cleveland.
28-30—Liquefied Petroleum Gas Association, annual convention, Kansas City.

May

4- 5—American Gas Association, Natural Gas Department, Houston, Rice Hotel.
15-22—International Petroleum Exposition, Tulsa.

JAMES E. DYER

Sinclair Promotes Dyer To Statistics Chief

James E. Dyer, director and vice president of Sinclair Refining Company, has been put in charge of an expanded department which will supervise transportation and distribution. He also will head up a newly established statistical department relating to company and industry operations.

During Dyer's 30 years with the company he has held almost every job from warehouseman to district manager and general manager of sales. In the war period he was secretary of the national committee on transportation of PIWC, transportation committee of PAW, District No. 1, and other related committees.

A native of Nebraska, Dyer grew up in Kansas and attended the Kansas City School of Law. He is a Navy veteran of World War I.

Byrnes MacDonald becomes assistant director of public relations and advertising for the company and its subsidiaries, it also was announced.

MacDonald joined the Sinclair organization in 1946 as executive assistant to the president and is a veteran of World War II. He was Secretary to the late Mayor LaGuardia of New York from 1940 until he joined the services.

Sunray Joins Bank In Tulsa Building Project

A new 24-story office building has been announced for Tulsa by First National Bank and Trust Company and Sunray Oil Corporation, which will jointly build it, each to occupy considerable space in it. It will be located at Fifth and Boston. The bank will occupy approximately five floors starting at the

GREATER SUCTION HEAD AVAILABLE

Vertical construction with suction at the bottom solves those jobs where suction conditions are difficult.

SINGLE STUFFING BOX—

in convenient location—can be packed or equipped with the Cameron Shaft-Seal.

SIMPLIFIED PIPING

Straight through piping above or below floor level.

HIGH EFFICIENCY—

requires smaller motors—reduces power costs.

THIS PUMP FITS MANY REFINERY JOBS

SMALL FLOOR SPACE

saves on erection and foundation costs.

SELF-VENTING

No troubles from vapor binding.

Class APHR and APKR
Heads to 90 ft per stage
Capacities to 12000 gpm

These pumps were designed especially for refinery service. Such features as: high efficiency, small floor space, single stuffing box, single or multiple staging, plus a complete range of sizes, make them the choice for many services. Ask the Ingersoll-Rand engineer for complete details. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York 4, N. Y.

71-10

COMPRESSORS • AIR TOOLS
ROCK DRILLS • TURBO BLOWERS
CENTRIFUGAL PUMPS • CONDENSERS
OIL & GAS ENGINES

Ingersoll-Rand
11 Broadway, New York 4, N. Y.

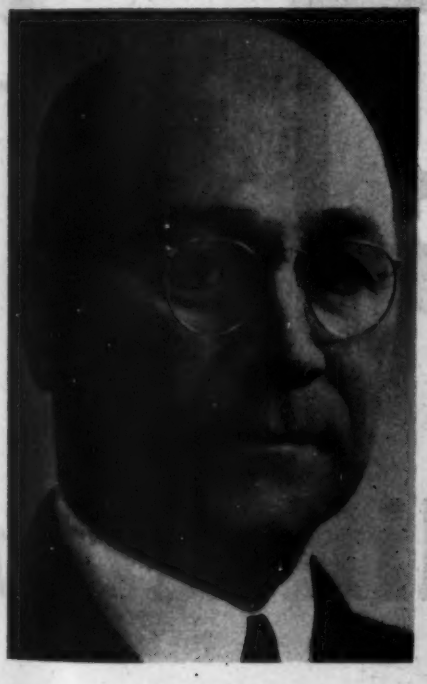
THE MONTH . . .

second floor elevation to be served by stairway and escalators from street level. Sunray also is expected to occupy as many as five floors of the new building.

It is not known when construction will start as plans are still in the consultation and negotiation stage. It is thought that actual building will require at least two years.

Dr. Snow Named Manager Of Pan American Plant

Effective September 1, Dr. H. R. Snow became plant manager of Pan American Refining Corporation's Texas City plant replacing P. J. Sweeny, who will devote his full time to the position of first vice president of the Refining Corporation and Mexican Petroleum Corporation of Georgia of which he is also first vice president. B. F. Babin succeeds Dr. Snow as assistant general superintendent, and P. A. Stewart, presently assistant department head, will



P. J. SWEENY

succeed Babin as head of the light oils department.

Also promoted is W. A. Sullender, assistant department head, who will succeed J. B. Hamblen as head of the catalytic and distillation department. Hamblen will be transferred to the Pan American Petroleum Corporation at Destrehan, La., to head the manufacturing department of that company.

Dr. Snow, in Texas City since 1942, got his master's degree in chemical engineering and his Ph.D. (1922) from the University of Michigan and became associated with Standard Oil Company of Indiana in 1925. In 1932 he became plant manager at the Neodesha, Kan., refinery. In 1942 he was named manager of a large butadiene plant which was to be constructed at Gary, Ind., but came on to Texas shortly afterward. He is married, has three children, is a member of the Dickinson school board and is otherwise active in civic affairs.

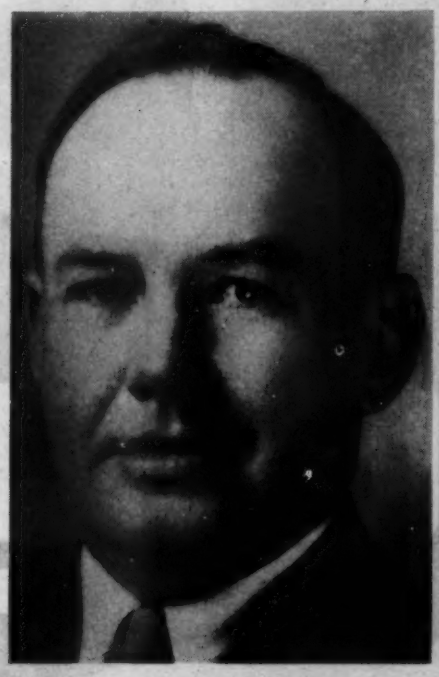
Babin has been at Texas City since the beginning of plant operations in 1933. He attended Louisiana State University and is a World War I veteran. He became connected with Standard Oil Company of Louisiana at Baton Rouge following which in 1923 he joined the Mexican Petroleum Corporation of Louisiana, at Destrehan, La., from which place he went to Texas City.

Telling Oil's Story Would Remove Threat of Control

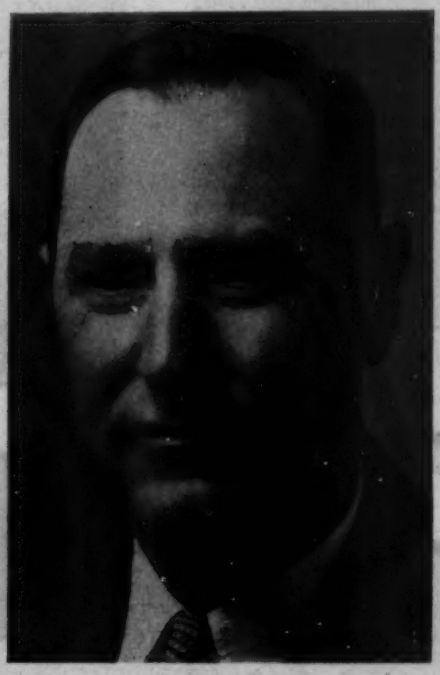
The threat of governmental regulation and the many misconceptions in the public mind concerning the petroleum industry can be removed by the effective cooperation of every oil man in the industry's nationwide program of public relations, Eric V. Weber, president of the Ohio Petroleum Marketers Association, and chairman of the Ohio-Kentucky-Tennessee District Committee for the industry's program, declared last month.

Speaking before the North Carolina Jobbers Association, Weber said that "too many people in high places are thinking too much about nationalization of basic industries" and unless business

Pan American Refinery Changes

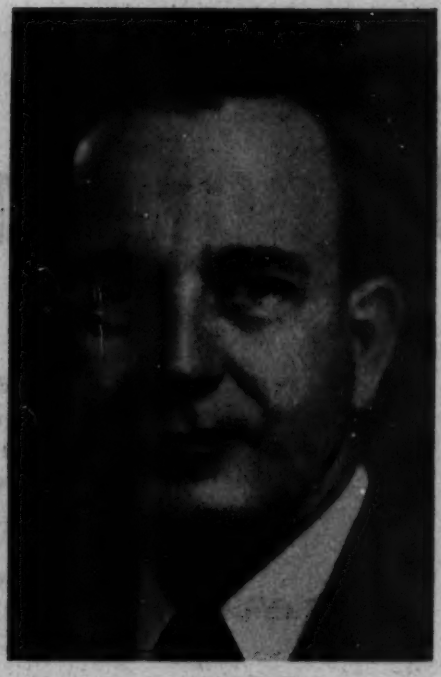


H. R. SNOW



B. F. BABIN

P. A. STEWART



W. A. SULLENDER

Ohio Return Bends

Stronger

Thanks to

Directional Solidificatio

★ Ohio Return Bends are designed to take advantage of the well-known principle of directional solidification. Since solidification of the steel casting progresses from the less heavy to the heavier sections, the feeding head is at the heaviest point. This permits the casting to feed itself. Liquid metal is provided constantly to fill center-line cavities.

The result is sounder, stronger Ohio Return Bends . . . free from shrinkage cavities or center-line weakness.

THE OHIO STEEL FOUNDRY COMPANY

SPRINGFIELD, OHIO

Plants at Lima and Springfield, Ohio

does something to reverse that trend in this country, "it can happen here."

The operation of wartime controls, he added, "made all of us apprehensive as to what might happen to our business, and it also convinced us that the less we have to do with 'controllers' and political mischief-makers, the happier we shall be.

"There is one way, and only one way, for us to avoid this constant threat of regulation and that is to remove all misconceptions in the public mind concerning our industry. If everybody is told the truth—and I know of nothing we have to conceal about our industry—and the truth is repeated with such frequency that all of the public is made to know it, I have no fear of undue future regulations."

Gulf Publishing Company Director Dies in Houston

R. P. (Dick) Swinsky, 48, a director of The Gulf Publishing Company, and for more than 22 years manager of the company's New York office, died in Houston September 13.

He resigned as vice president of the company July 1 to form his own business, which was still in the organization stage at the time of his death. Before he joined Gulf Publishing and took charge of advertising in New York, he had worked for Houston's three daily newspapers. A native of Dallas, and brother of the late Albert Swinsky, advertising director of the Dallas *Times-Herald*, he was a substantial stockholder in the Times-Herald Publishing Company. As a vice president of The Gulf Publishing Company, he was considered an authority on the marketing of oil field equipment and supplies.

He was a member of the Nomads and the Dotted Line Club of New York.

Funeral services were held in Houston with interment in Dallas.

Arnold Smith Is Named Monsanto Canada Director

Arnold H. Smith, acting managing director of Monsanto (Australia) Pty. Ltd., has been elected vice president and member of the board of directors of Monsanto (Canada) Ltd., and will assume his duties January 1, 1948.

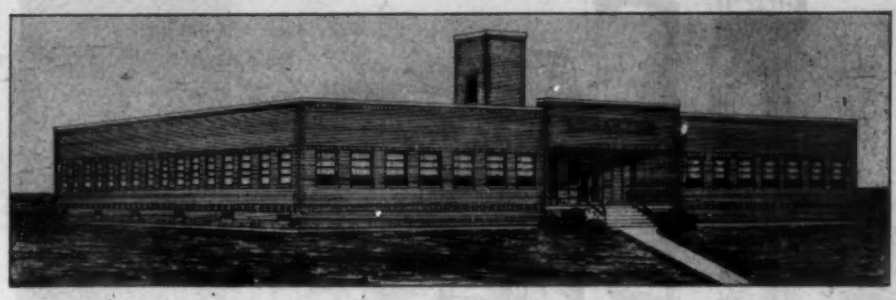
Irving C. Smith, vice president and member of the board of directors of Monsanto (Canada) Ltd., has resigned effective January 1 to accept promotion to assistant general manager of Monsanto's Western Division, with headquarters at Seattle, Wash.

Arnold Smith joined Monsanto in 1922 and Irving Smith, a native of Canada, came to Monsanto in 1944.

Forms Own Company

Joseph Lichtenstein has left the Foster Wheeler Corporation with whom he has been associated for the last 18 years to establish an organization specializing in the design and application of pumps, cooling towers and diffusional equipment. His offices are located at 123 William Street, New York 7.

Proposed Cities Service Testing Laboratory



A new technical service laboratory on the site of the company's East Chicago, Indiana, refinery, will be built by Cities Service Oil Company, to be used for primary sales service, including service testing and other forms of product evaluation. A one-story U-shaped building, the laboratory will serve as the central testing point for product quality control during manufacture and will develop test standards for refinery laboratory use.

Special investigations will be conducted relating to refinery operation such as corrosion control, waste disposal, chemical treatment and general processing improvement. A complete analytical laboratory will be equipped for chemical analyses of all kinds, with special emphasis on petroleum and its products.

Personnel at Okmulgee, Okla., under the direction of T. E. DeVilliers, will be transferred to the new laboratory upon it completions.

President of Fluor Dies

Peter E. Fluor, 52, president and chairman of the board of The Fluor Corporation, Ltd., Los Angeles, died September 10 at his some in Anaheim, California.

With the company since 1915, and president since 1943, Fluor was largely responsible for the development of The Fluor Corporation from a small, general contracting concern to its present status as one of the major firms engaged in the design and construction of processing plants for the oil, gas and chemical industries. With his father, the late J. S. Fluor, Sr., he was among the first to enter into oil field construction work in California.

PETER E. FLUOR

A native of Wisconsin, Fluor came to California in 1912. He served in World War I as a lieutenant in the Army Air Force. Among others he belonged to the American Petroleum Institute, California Natural Gasoline Association and the Western Oil and Gas Association.

Petro-Chemistry Research Is Endowed by Tom Slick

Tom Slick, oil man and rancher of San Antonio, announced last month the establishment of Southwest Research Institute, a non-profit scientific organization "to help Southwestern industry produce new products, develop new processes, profitable uses for waste products and similar projects." Planned is a $1 million petroleum-chemistry research laboratory in Houston, site to be chosen, where 20 scientists will work on problems dealing with pipe line and oil field equipment, electronics, corrosion, oil and gas technology, etc.

Governors include C. F. Urschel, Earl Slick, W. M. Hammond, Leroy Denman, Jr., John Cox, J. V. McGoodwin, and Dr. Judson Swearingen, all of San Antonio, George Strake and Col. W. B. Bates of Houston, and James Hewgley of Tulsa.

In addition to the governors, trustees to be named later will include men from all major population centers of the Southwest, and will serve in an advisory capacity.

Efficient Independents' Opportunity Said Large

Charges that the large oil companies are engaged in a conspiracy to destroy or restrict opportunity for the remaining 34,000 enterprises in the oil industry are "warmed-over repetitions and discredited accusations," Robert G. Dunlop, president of Sun Oil Company told the National Petroleum Association in annual session last month at Atlantic City. These charges should be met, Dunlop declared.

The speaker branded as preposterous the contention that the oil industry offers an illustration of how industrial concentration is threatening independent business; "in fact, there has been a decrease in economic concentration in the oil in-

Newark Wire Filter Cloth is outstandingly successful in refinery filtration.

Newark Cloth is woven firmly and uniformly from carefully selected wire, is free from looseness and waviness, requires no rolling to make it lie flat and snug in the filter, and has the special Newark overlap weave insuring strength and long service life.

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dustry since the Standard Oil trust was dissolved 36 years ago."

Dunlop agreed that during the last seven years a number of small refineries had been shut down, "but that is part of a trend because petroleum refining to be efficient today must be done on a fair-sized scale."

He said that the industry by its very nature requires big, strong companies but pointed out that there is a place and "abundant opportunity for smaller companies if they are efficient." The efficient small operator sets the competitive pace of the industry, he said.

H. T. Haslam, vice president of Standard Oil Company (New Jersey) pointed out that petroleum's public relations program is even more important now because public thinking should be set straight on current company earnings as well as the tight supply of products.

NPA re-elected all of its officers with J. B. Fisher, Kendall Refining Company, president.

Raaen Appointed Head of UOP Company Laboratories

Cól. J. C. Raaen has been appointed general manager of Universal Oil Products Company laboratories at Riverside, Ill.

A native of Minneapolis, Colonel Raaen spent his early life in Chicago. After graduating from West Point in 1918, Colonel Raaen obtained his B.S.

COLONEL J. C. RAAEN

degree from Massachusetts Institute of Technology. He was graudated from The Infantry School, Fort Benning, Georgia; the Ordnance School, Watertown, Arsenal; Command and General Staff College, Fort Leavenworth, and the Army Industrial College, Washington.

During his 29 years in the Army, Colonel Raaen was actively associated with

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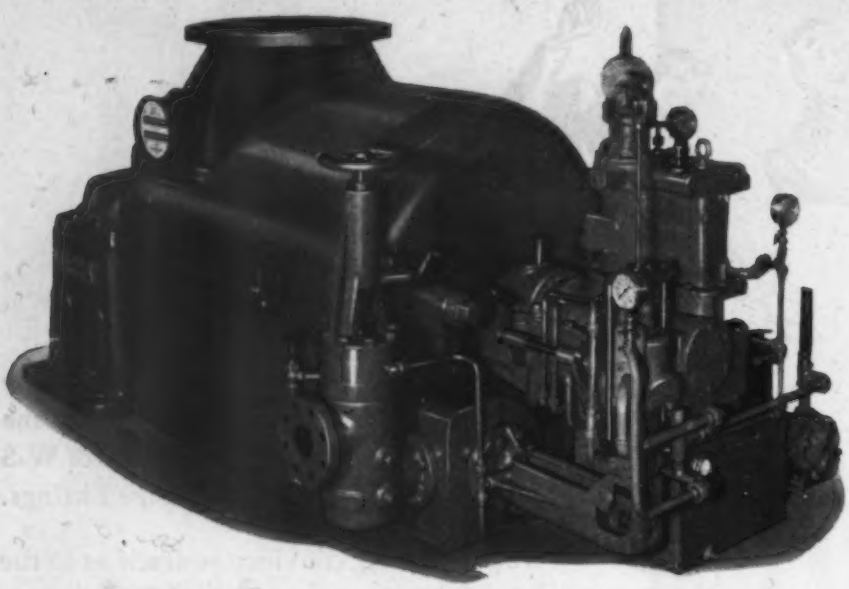

One of two MURRAY multistage steam turbines, designed to deliver 685 horsepower on steam at 110 pounds and exhausting to 26½ inches Hg vacuum, furnished to drive high speed centrifugal compressors for refrigeration in one of the most prominent Southern Hotels. A third unit has recently been shipped. Equipment includes variable speed oil relay governor, trip and throttle valve, strainer surrounding the double seated balanced governor valve, and force feed lubrication.

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STEAM TURBINES

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Sales Representatives for Murray products are located in all principal cities.

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

THE MONTH...

all phases of research and development work affecting ordnance. He also had experience in management and personnel problems.

Colonel Raaen was awarded the Legion of Merit and the Distinguished Service Medal. He is married and has one son who is an instructor in ordnance at West Point.

C. G. Gerhold, formerly manager of Universal Riverside laboratories, is being transferred to the administrative department as assistant to Edwin F. Nelson, vice president. Coordinating all research and technical activities of Universal will be his assignment.

Western Refiners Meet

The Western Petroleum Refiners Association will hold a fall regional technical meeting October 24 at the Garrett Hotel, El Dorado, Ark., the subject to be "Lubricant Additives," which will be presented by J. H. Baird, Lubrizol Corporation, Cleveland, Ohio.

This discussion will cover new developments in the lubrication oil and gear lubricant field.

Chairman will be A. W. Trusty of the Arkansas Fuel Oil Company, Shreveport, La. A tour of inspection through the Lion Oil Company plant will start at 1 p. m., after which the technical session will be held.

Johnson Transferred by Sunray to Duncan Plant

R. L. Johnson, superintendent of Sunray Oil Corporation's refinery at Santa Maria, Calif., has been transferred to

R. L. JOHNSON

Duncan, Okla., where the company is opening its recently purchased $14 million plant acquired in a sale by the War Assets Administration. K. D. (Kennie) Ford, Johnson's assistant at the Santa

THE MONTH . . .

Maria refinery, has been advanced to the superintendent's post.

Hary F. Arnold, Santa Maria refinery sales manager, has been named to enlarged responsibilities as office, sales and credit manager for the company at Santa Maria. Ford will be in charge of crude oil purchases, pipe line and refining operations.

Johnson was called to Tulsa general offices on September 1 as special assistant to Vice President F. L. Martin, in expediting a remodeling and expansion program at the company's new Duncan refinery.

Named to Research Staff Of Standard of Indiana

Harold D. Allen and Carl M. Marberg have been appointed research associates on the staff of Standard Oil Company (Indiana) and will be located at Standard's new research laboratory at Whiting, Ind. They will assist W. H. Bahlke, associate director of research, in the company's research in the field of chemicals from petroleum.

Dr. Allen comes from the Colgate-Palmolive-Peet Co., where he has had charge of pilot-plant and process-design work in the division of development engineering. He received his Ph.D. from Cornell in 1932.

Dr. Marberg has been chairman of the organic chemistry research section of the Midwest Research Institute. He previously spent several years in the pigments and plastics industry, and also served as assistant professor in biochemistry at the University of Chicago. He received his Ph.D. from that institution in 1930.

High Ethylene Recovery by Commercial Hypersorption

Charging 76,900 standard cubic feet per hour of mixed gases composed mainly of hydrogen, methane, nitrogen and but 5.7 percent ethylene, a commercial hypersorption unit is now recovering 7000 to 7500 pounds per day of ethylene, some 96 percent of the total ethylene feed to the unit.

Tabulated data below, shows the individual components in both the charge and the ethylene product.

COMPONENT	Volume Percent	
	Feed	Product
Hydrogen	37.2	....
Oxygen	0.3	.1
Nitrogen	6.0	.1
Carbon Monoxide	1.0	....
Methane	49.2	*
Acetylene	0.3	3.7
Ethylene	5.7	92.0
Ethane	0.1	1.0†
Carbon Dioxide	0.2	3.1
	100.0	100.0

* Note that there was no methane contamination in the ethylene product.

† For this particular application it was not necessary to separate the ethane from the ethylene.

The hypersorption process was developed by the Union Oil Company of California, the commercial unit being designed and fabricated by the Foster Wheeler Corporation.

HUGH W. FIELD

Field Succeeds Delbridge

T. C. Delbridge, manager of The Atlantic Refining Company's research and development department, retired October 1 and his successor was H. W. Field, previously his assistant. Delbridge, with Atlantic for 38 years, has been active in ASTM and API work.

Field joined Atlantic in 1928 as a member of the Research Department, after receiving a degree in chemical engineering from the University of Pennsylvania. He was elected a director of the company last year and was appointed a member of the manufacturing committee.

During the last war, he was a member of PAY's Aviation Gasoline Committee of District No. 1, and chairman of the Synthesis Subcommittee of PIWC's Technical Advisory Committee.

Europen Situation in Europe Complicates Oil Picture

European oil requirements, present and prospective, are increasing the burden of meeting petroleum demands.

Aid to Greece and Turkey has intensified the American military supply problem, it was pointed out while if Congress approves the Marshall plan for European relief the drain will be increased that much more.

"How much oil we can furnish without impairment of our own economy is a matter that will require close scrutiny," Walter S. Hallanan, chairman of the National Petroleum Council, said in an address. "The industry is leaning backward on the side of its public responsibility despite existence of the greatest sellers' market in the history of petroleum."

Army-Navy Petroleum Board said that the Greco-Turk aid program is making it necessary for it to call for more than previously booked quantities of various petroleum products. Actual requirements of these two countries, yet to be determined, will complicate the situation considerably, the board indicated.

Arc Welding Foundation Resumes Scholarship Plan

Trustees of The James F. Lincoln Arc Welding Foundation have announced rules of their Annual Engineering Undergraduate Award and Scholarship Program. This program started in 1942 but was interrupted by the war. Recently upon the advice of the deans of engineering of a number of prominent engineering schools, it was decided to resume the program.

The program contains two interdependent plans. Under the award plan, engineering students of various engineering schools and colleges will submit papers on arc welded design and the use of welding in maintenance of machines and structures. Under the scholarship plan, scholarships will be allocated to the schools in which the three highest award recipients under the award program are registered.

Copy of the rules and conditions may be obtained by writing The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

Socony-Vacuum Awarded Trophy for Safety Record

For the second time in two years, the manufacturing department of Socony-Vacuum Oil Company, Inc., has achieved the best safety record of any large manufacturing department in the oil industry, receiving a trophy at the National Safety Congress early this month. Later it will be presented Socony-Vacuum's manufacturing committee at a meeting in Beaumont, Texas, after which it will be circulated among the company's refineries.

The Socony-Vacuum safety record was achieved by an average of 8275 employes during a 12-months period who worked 17,061,988 hours with an average lost time of only 2.50 days of each 10,000 hours worked.

Stanolind Safety Award

The National Safety Council has presented Stanolind Oil & Gas Company its "Distinguished Service to Safety Award" which is given to companies which have developed an outstanding record in accident prevention. Only about 148 companies have received this award to date. Stanolind is the twelfth company in the petroleum industry to receive this honor and the first organization in Oklahoma to receive the award.

During 1946 Stanolind had only 39 percent as many accidents as during 1937, and 20 percent fewer accidents than in 1945. The Stanolind accident rate is only about one third of the average for the petroleum industry as reported to the National Safety Council.

Creosote from Petroleum

Two new West Coast plants are using a creosote-type of preservative distilled from petroleum oil tar, J. F. Linthicum, Chicago, president of American Lumber and Treating Company, reported last month.

Domestic creosote production remains below prewar requirements but blending practices and extensive use of substitutes are stretching the nation's supplies, he said. Northern railways have employed lignite-tar creosote produced from lig-

CHEMICAL MAGIC

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BLAW·KNOX

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nite coal. Watergas-tar creosote also is used. Attempts have been made to fortify petroleum with oil-soluble toxic compounds. A number of new treating plants built during the war and unable to obtain creosote are using such fortified mixtures.

Government Issues Specific Quotas to 52 Refiners

Specific quotas of gasoline, kerosine, distillate fuel oil and residual fuel oils to be furnished the government during the period ending next June 30 have been set for 52 refiners by Secretary of the Interior J. A. Krug, and the individual companies have been asked to meet at least the specific amounts set and as much more as possible.

Krug pointed out that the industry has repeatedly assured that the government's requirements would be met. However, he added, these promises have not been made good, and unless they are an emergency will develop.

Overall needs of the government have been set at 52,351,000 barrels for the current half of the fiscal year and 54,096,000 barrels for the first half of the 1948 calendar year, something over 80 percent being for the military.

The military has filled between 80 and 90 percent of its requirements and is in good shape as to deliveries in the near future; its deficiency, however, will fall almost entirely in the 1948 period and is causing considerable concern.

Eisenhart Heads NBS Statistical Laboratory

Dr. Churchill Eisenhart has been appointed head of the Statistical Engineering Laboratory of the Bureau of Standards National Applied Mathematics Laboratories, Dr. E. U. Condon, bureau director, has announced. Dr. Eisenhart is noted for his work in mathematical statistics and its applications in the biological sciences, industry, and engineering.

Other Bureau announcements include: Dr. John H. Curtiss, named chief of the recently-established National Applied Mathematics Laboratories at the Bureau; Dr. Arnold N. Lowan, named chief of the Computation Laboratory of the National Bureau of Standards; Albert S. Cahn, appointed executive officer of the Institute of Numerical Analysis, recently set up.

Steel Postwar Record

The steel producing subsidiaries of United States Steel Corporation late last month poured their 50 millionth ton of steel since the end of hostilities in World War II, Benjamin F. Fairless, president of United States Steel, announced.

"Although our postwar production was limited by strikes during 1946 and 1947, these subsidiaries have never in times of peace produced such a tremendous tonnage of steel in the brief span of a little more than two years," he said.

CNGA's First President Welcomed

The California Natural Gasoline Association's first president, Paul D. Barton, was welcomed to the association's 264th meeting by F. J. Colton, CNGA's 22nd president. Barton, now Sun Oil Company's chief engineer, was with Richfield Oil Corporation at the time of CNGA's founding. Those in the picture, left to right, are M. W. Kibre, W. A. Kirk, Paul D. Barton, H. L. Eggleston, F. J. Colton, M. L. Arnold, J. A. Campbell and H. R. Linhoff. All are past presidents of CNGA except F. J. Colton, current president; W. A. Kirk, current vice president; and J. A. Campbell, vice president during the 1926 term.

Jersey Standard Describes Its Role in Worldwide Expansion of the Oil Industry

Standard Oil Company (New Jersey) and its affiliates throughout the world are in the midst of one of the greatest expansion programs in the company's history in order to meet consumer requirements for petroleum products, *The Lamp*, company publication, said last month. The program will include increased refinery capacity and additional pipe lines as well as extensive exploration and drilling.

Postwar petroleum demands were expected to drop sharply after war requirements were cut back, *The Lamp* points out, but instead they climbed to an all-time high, with economists estimating that by 1951 the industry will be asked to provide for world demand of nearly 3.75 billion barrels of crude and products annually, a 35 percent increase over 1945.

Jersey's domestic affiliates alone will spend about $121 million on producing activities in 1947. Humble Oil & Refining Company is drilling nearly 700 wells annually, while The Carter Oil Company is drilling nearly 200 wells a year.

Domestic affiliates also are making capital expenditures of nearly $60 million this year for modernization and construction of refinery facilities and next year plan to spend $75 million.

Refinery Expansion Plans

The Standard Oil Company of New Jersey, principal manufacturing and marketing affiliate of Jersey, plans an outlay of $50 million to modernize and expand refineries and other manufacturing facilities. At Linden, N. J., a two-year program of expansion in the Bayway refinery will include the world's largest catalytic cracker and new pipe stills. At the Baton Rouge, La., refinery the expansion program is being carried out with no slackening in the operating rate of existing equipment. Here new pipe stills are planned and two catalytic crackers are undergoing modernization to increase their capacity 8000 barrels a day each. Other modernization and expansion projects also are under way at the company's refineries at Baltimore, Md., and Charleston, S. C.

Meanwhile the Humble Company is spending $5 million expanding its large Baytown, Texas, refinery installations and another $2 million to enlarge pipe line outlets from West Texas to Gulf ports.

In Venezuela the Creole Petroleum Corporation has under way the largest single building project yet undertaken within the Jersey organization. This includes construction of a new refinery at Amuay Bay, a large pipe line from the Maracaibo oil fields, a tanker terminal and a town to house the families of 2000 Venezuelan workers. The Amuay Bay installations, costing more than $98 million, will be a major factor in increasing the output of refined products in the Caribbean area.

The Caribbean as a whole, and Venezuela in particular, today is furnishing nearly half of Europe's oil imports. Although further increases in European demand which in 1951 is expected to be 63 percent over 1946, will be met chiefly by oil from the Middle East, Caribbean production is expected to rise by more than 350,000 barrels a day and refinery capacity nearly 200,000 in the five years from 1946 to 1951, the article states.

Middle East Activities

Although some final agreements with Jersey's European partners in Middle East oil concessions are still being negotiated, *The Lamp* points out the company hopes to be serving the increased

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demand of European consumers from this area when previously announced facilities are completed. These include pipe lines connecting the Persian Gulf with the Mediterranean to save 2500 of the 3500 miles of water route via the Red Sea.

In Europe proper, Jersey's affiliates are expanding manufacturing facilities at Fawley, on the southern coast of England and at Port Jerome, France. The Fawley refinery will be modernized at a cost of more than $140 million to increase capacity from 13,000 barrels daily to 120,000 barrels by 1952. At Port Jerome the problems in restoring the refinery to prewar capacity include not only rebuilding war-damaged facilities but a search for equipment carried away by the Germans. Some units have been found as far away as Austria.

The Jersey program is part of the greatest expansion effort in the history of the oil industry, one which calls for an expenditure within two years of $4 billion, equal to 20 percent of the capital outlay invested in the oil business since it began.

Metal Congress Exhibit In Chicago This Month

With Chicago as its 1947 meeting place, the 29th annual National Metal Congress and Exposition will hold its first seven-day session October 18-24.

According to W. H. Eisenman, managing director of the Exposition and national secretary of the American Society for Metals, sponsors of the event, approximately 375 companies and organizations will display and operate metal working equipment and products during the seven days. Exhibits will occupy all available floor space on both levels of the International Amphitheatre. Attendance on the two opening days will be by invitation.

The National Metal Congress will again combine technical sessions of the American Society for Metals, the American Welding Society, the Iron and Steel and the Institute of Metals Divisions of the American Institute of Mining and Metallurgical Engineers, and the American Industrial Radium and X-Ray Society.

Marshall Plan Refinery Capacity Is Announced

Among the self-help measures contemplated by European countries included in the Marshall plan is one to increase their petroleum refining capacity by 240,000 barrels daily by 1951. It was said that the oil refinery program sought a crude throughput capacity 2½ times the prewar figure.

Foreign Oil Policy

Recommendations as to United States' oil policy, as drafted by the State Department's technical petroleum committee, is about complete. The project, under way for more than a year, goes first to Undersecretary W. L. Clayton's executive committee on foreign economic policy.

ROBERT I. STIRTON

Stirton Joins Oronite

Oronite Chemical Company of San Francisco has announced appointment of Robert I. Stirton as manager of its product development division.

Stirton takes over the duties after a wide experience in the oil business since his graduation from the California Institute of Technology in 1934, where he received his Ph.D. degree in chemical engineering and chemistry.

Stirton began his career as a research chemist, later gaining sales experience during a three year tour of duty at Singapore ending in 1940. He returned to the field of research as supervisor and later assistant manager of the research department of a major oil company in southern California.

Plane Uses a Liquefied Gas In Experimental Flight

A new market for liquefied petroleum gases was indicated by the test flight of a plane recently, in which a mixture of propane and butane was used as the fuel. The 20-minute flight was under the supervision of the Civil Aeronautics Administration. Experiments conducted for the past year indicate that liquefied gases used as a fuel for plane engines have definite possibilities.

The flight took place at the Municipal Airport in Oklahoma City with Fred Reese, manager of the Regan Flying Service, Shawnee, at the controls. L. L. Hughes of Hughes Distributing Company, also of Shawnee, conducted the test and has been experimenting for the past year with liquefied petroleum gases as a fuel for airplanes. Further flights are planned to explore the use of the propane-butane mixture in taking off and landing.

Ohio Oil Transfers

The Ohio Oil Company has transferred its top refining and marketing personnel from the company's Robinson, Ill., refinery to its general office in Findlay, Ohio. The move was made in order "to centralize the management of the refining and marketing departments and to obtain a closer correlation between those departments and the general management."

Involved in the transfer are R. E. Luton, manager of the refining division, and M. W. Nicholas, his assistant, and L. B. McCammon, manager, refined products supply and transportation departments, and A. I. DeWeese, his assistant.

Gulf Sets Up Employe Relations Department

A new employe relations department created by Gulf Oil Corporation began functioning on October 1. Located in Pittsburgh, the new unit will be under the direction of V. H. Ludwig who will have the title of general manager and who will be responsible to the company's president.

Ludwig joined Gulf as a traveling inspector and auditor in 1920. Since November, 1940, he has been assistant general manager of refined oil sales with three division offices under his direction.

Indiana Standard Wins Annual Report Award

The 1946 annual report of Standard Oil Company (Indiana) was judged as the best of the petroleum industry in the final considerations of the independent board of judges in the annual report survey of *Financial World*. The bronze "oscar of industry" trophy was presented to Dr. Robert E. Wilson, chairman of the board, and A. W. Peake, president of the company, in New York on Friday, October 10. In this industrial classification, Standard Oil Company (New Jersey) was runner-up, while Union Oil Company of California came in third.

Monsanto Promotions Announced for Month

Six staff members of Monsanto Chemical Company's Central Research Department at Dayton, Ohio, were promoted effective October 1 as follows:

Dr. Wendell P. Metzner to be associate director of research in the rubber service department of the organic chemicals division at Nitro, W. Va.

Dr. Reid G. Fordyce to be manager of sales development of the plastics division at Springfield, Mass.

Dr. Rudolph L. Heider and Alfred B. Craig to be group leaders of the process research and plastics evaluation groups, respectively, at the central research department.

Dr. Earl C. Chapin named acting group leader of a polymer research group at Dayton, replacing Dr. Fordyce. Dr. Metzner has been replaced as acting group leader of another polymer research group by Dr. George L. Wesp.

Other Monsanto changes include:

Dr. E. S. Blake appointed assistant director of research for Monsanto's Merrimac Division.

Robert L. Rickenbacher appointed senior sales representative for the Plastics Division on the Pacific Coast, replacing R. J. Lambert, who recently resigned from Monsanto.

R. L. Bauer and R. E. Lenz appointed assistant managers of the process sec-

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tion of the General Engineering Department. Bauer to be the senior assistant and be primarily responsible for the technical phase with Lenz responsible for the administrative phase.

C. L. Parish, electrical engineer for the company's Phosphate Division, appointed maintenance superintendent at Anniston succeeding Herbert O. Tittel, appointed production superintendent of Monsanto's plant at Trenton, Mich.

Charles F. Booth named a senior research chemist at the central research department at Dayton, Ohio, to be engaged in inorganic chemical research.

Pittsburgh Consolidation Lists Personnel Changes

Additional appointments to the staff of the Research and Development Division of Pittsburgh Consolidation Coal Company have been announced as follows:

R. V. Safford to be in immediate charge of the company's coal gasification pilot plant at Library. For the past four years he has been with the Stanolind Oil and Gas in complete charge of the construction, maintenance and operation of the Synthol pilot plant at Tulsa.

Thomas G. Reynolds appointed chemical engineer on coal gasification. His experience includes four years with Continental Oil, five years as process and project engineer for Foster Wheeler, and war experience on the atomic bomb project.

J. Hunter Johnston appointed control supervisor in charge of accounting and purchasing sections and assigned to the service department.

Warren R. Eakin appointed economist and assigned to the service department.

Other Pittsburgh Consolidation appointments include:

Irving H. Welinsky, Ph. D., appointed research chemist and assigned to general research for the division. Dr. Welinsky the past five years was with Houdry Process Corporation as head of the process research section, and prior to that was with Magnolia Petroleum Company at Dallas.

Jack F. Chapin appointed chemical engineer and assigned to operational work on the coal gasification pilot plant.

William E. Lough appointed chemical engineer to be employed on the coal gasification pilot plant.

Sumatra Refinery Ready

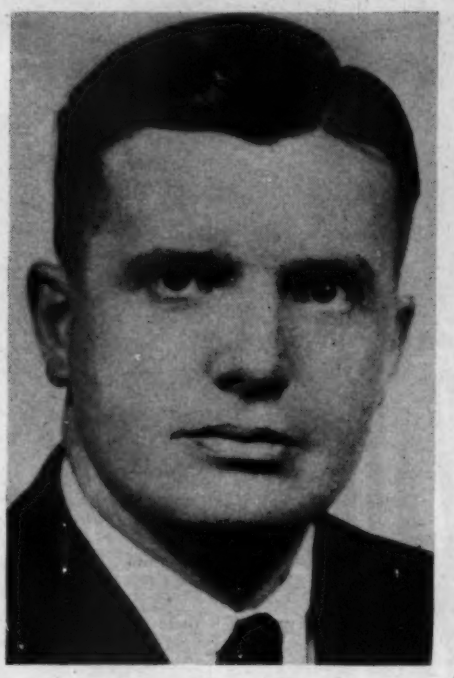
Standard-Vacuum Oil Company's affiliated Palembang, Sumatra refinery resumed operations early this month after having been closed since 1942 when it suffered war damage. It will be operating by October's end at a rate of 20,000 barrels daily, will increase to 32,000 barrels by February and later to its prewar capacity of 45,000 barrels daily.

Chemists Honor Egloff

Dr. Gustav Egloff has been re-elected chairman of the petroleum division of the American Chemical Society and vice president of the society. Dr. W. E. Kuhn of The Texas Company was elected vice chairman.

Edward Everett Joins Marshall-Moorman

Edward F. Everett, Jr., has joined the Marshall-Moorman Development Company, specialists in new applications of the Fluid catalyst technique. Formerly a chemical process engineer with the M. W. Kellogg Company, Everett has been active since 1945 in process development and design of the Fischer-



EDWARD F. EVERETT, JR.

Tropsch method. During the war he was engaged in designing hydroforming plants and butadiene plants for the synthetic rubber program.

Everett received both his bachelor's degree in chemical engineering practice in 1936 and his master's degree in chemistry in 1937 from the Massachusetts Institute of Technology. He became associated with the Kellogg firm in 1937.

Demand Gain Shown

U. S. demand for petroleum products during the first half of 1947 was 10.12 percent higher than for the same period, 1946, itself a record year, the API reported during September. Exports for the same period increased 4.32 percent.

In barrels consumption was 964,209,000 against 875,584,000 for the previous year.

Refinery operations for the period were maintained at more than 90 percent rated capacity for the 12 weeks ended September 1, the report declared.

Refinery for Holland

California-Texas Corporation is planning to erect a 20,000-barrel-a-day refinery on the Rhine River in Holland for which a 160-acre site 4 miles west of Rotterdam has been acquired. The company is a jointly-owned subsidiary of Standard Oil Company of California and The Texas Company which plans to spend $18 million on the project. To be operated by Caltex Petroleum Maatschappij (Nederland) N. V., incorporated in Holland, it is scheduled for 1950 completion.

Smith Named by Creole To Be Head of Refining

L. G. Smith has been named vice president in charge of refining operations of Creole Petroleum Corporation. Smith became associated with Standard Oil Company (New Jersey) about a year ago after having been in the petroleum business for more than 30 years. He is now in Venezuela on an inspection tour. He will maintain offices in New York.

R. W. Miller, with Creole since September, 1944, was elected vice president in charge of Creole's export sales of crude and products.

Underground Gasification Experiment Called Success

Gases ranging from 47 to 200 British thermal units per cubic foot and averaging 108 cubic fet per pound of coal consumed, with both figures probably subject to considerable improvement, were produced last winter in a seven-week experiment in underground coal gasification conducted by the Bureau of Mines and the Alabama Power Company at Gorgas, Ala., according to the detailed report recently made available.

Using various methods of operation, the bureau determined that gases could be generated specifically for use for generating power or suitable for synthesis purposes. During the course of the experiment, it is estimated that 236 tons of coal were burned completely and 164 tons were coked.

While no consideration was given commercial cost factors, the experiment determined that coal in place could be burned successfully, that the burning could be controlled, that the action of the roof appeared favorable, and that the quantity and heating value of the gas produced per pound of coal burned varied with the method.

In preparing for the test, the experimental area at the Gorgas mine was isolated from adjoining coal by outcrops on three sides and an open cut on the fourth side. A U-shaped mine was developed in the coal bed, lying horizontally 30 feet under a hilltop, to form a pillar of solid coal 40 feet wide and 150 feet long inside the "U."

Five types of blasting were used to produce gas-air, oxygen-air, oxygen-air-steam, oxygen-steam and steam blasts. By regular sampling and analyses of gases given off, it was determined that the first three methods produced gases that could be used for generating power, while the oxygen-steam and steam blasts yielded gases suitable for synthesis purposes.

At the conclusion of the gas-making runs, the mine was cooled first with steam and then with water to permit examination of the underground residue and to measure the amount of coal burned. It was estimated that 236 tons of coal had been burned completely and 164 tons were coked during the combustion period.

Instead of falling as anticipated, the roof rock became plastic under the intense heat and expanded and settled down on the mine floor directly behind the reacting coal face. Tests showed that this roof action resulted in a uniform size opening for air and gas passage along the coke-rock interface.

Of the five types of blasts, air alone

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was used most frequently during the experiment. For each pound of coal burned, this method produced an average of 108 cubic feet of gas having a weighted average of 47 Btu per cubic foot. Comparative heating values for other methods were 200 Btu per cubic foot with steam runs following air blasting; 50 Btu for the air-oxygen blast; 110 Btu for the air-oxygen-steam blast; and 135 Btu for the oxygen-steam blast. These average results are considerably lower than were obtained under the most favorable conditions during the investigation.

A copy of the publication, Report of Investigations 4164, "Experiment in Underground Gasification of Coal, Gorgas, Ala.," may be obtained by writing to the Bureau of Mines, Department of the Interior, Washington 25, D. C.

Refinery Maintenance Firm Lists Construction Projects

Among the plant projects under construction by Refinery Maintenance Corporation, 2500 North Alameda Street, Compton, Calif., are the following:

Additions to the crude unit of Associated Oil Company, Avon, Calif.; additions to absorption plant of Union Oil Company, Brea, Calif.; additions to coking unit of Union Oil Company at Oleum, Calif.; construction of a natural gas cycling plant at Three Rivers, Texas, for Western Natural Gas Company, and construction of a natural gasoline plant for Barnsdall Oil Company at Newhall, Calif.

McKenzie Promoted

John H. McKenzie has been named manager of the safety department of General Petroleum Corporation.

McKenzie, with General since 1929, entered the company's fire prevention department in 1934 and in 1942 became fire and safety inspector at the company's Torrance refinery. With Stan Clithero, also of G.P., he is co-author of various works relating to safety procedure.

Kellex Research Director

H. Hugh Willis, specialist in electronics, has been appointed director of research and development of The Kellex Corporation, atomic energy subsidiary of The M. W. Kellogg Company.

Willis was formerly chief research director and vice president for Sperry Gyroscope Company, Inc., and vice president for engineering and product development of Eversharp, Inc. During the war he was a member of the radar section of the National Defense Research Committee.

New Gasoline Plant

American Republics Corporation and Houston Oil Company have let contract for $3 million natural gasoline plant in the Silsbee field Hardin County, Texas. Gasoline Plant Construction Corporation, Houston, was the successful bidder and work is slated to start soon.

JOHN E. WEBER

Weber Joins Project Firm

John E. Weber has joined the engineering staff of Project Engineering Company of New York as sales engineer. Weber formerly was connected with the M. W. Kellogg Company in charge of piping design of oil refinery units and later with its subsidiary, the Kellex Corporation as division engineer. He supervised the designing and drafting of the Clinton Engineer Work's gas division plant at Oak Ridge, Tenn. for the mechanical separation of uranium 235 from uranium 238.

Prior to his connection with Kellogg, Weber was a member of the engineering staff of Hardy S. Ferguson & Company consulting engineers on pulp and paper mills, steam, power and hydroelectric plants.

Chicago Section of ACS To Hold Technical Session

In conjunction with the 114th AAAS meeting, December 26-31, 1947, at Chicago, the Chicago Section of the American Chemical Society will hold its third All-Day Technical Conference on December 26 at Hotel Sherman. A joint three-day chemistry program will be featured by three symposia organized by the Chemistry Section of the AAAS and by a series of divisional meetings conducted by the Chicago Section of the ACS.

Although this conference is under the sponsorship of the local Section, contributions from other areas will be welcome.

Wertz Heads Vickers

John S. Wertz has been elected president of Vickers Petroleum Company, Inc., succeeding the late C. L. Henderson. Wertz has been with Vickers for 27 years.

Mason C. Lyons was named secretary-treasurer which post Wertz previously had held. Lyons also became a director. James J. Brown, land superintendent, was made a vice president.

Rayner Resigns

Charles Rayner last month submitted his resignation as State Department petroleum advisor. His post, as such, will not be filled, it was reported, and this would make John Loftus, chief of the petroleum division, the top ranking petroleum officer of the department.

Rayner is expected to make a connection with some oil company engaged in foreign operations.

Two New Directors

Standard-Vacuum Oil Company has announced election of A. W. Bourne, Jr., and H. W. McCobb to the board of directors. Bourne is general manager of the company's China division while McCobb heads the producing department.

Senator O'Mahoney Charges That Few Oil Companies Fix Prices for Industry

Senator Joseph C. O'Mahoney in a talk late last month at Cleveland to an American Bar Association committee urged enactment of federal laws to define powers, duties and responsibilities of all economic organizations, change of tax laws to provide for investment of private capital in new independent enterprise and rigid enforcement of anti-trust laws.

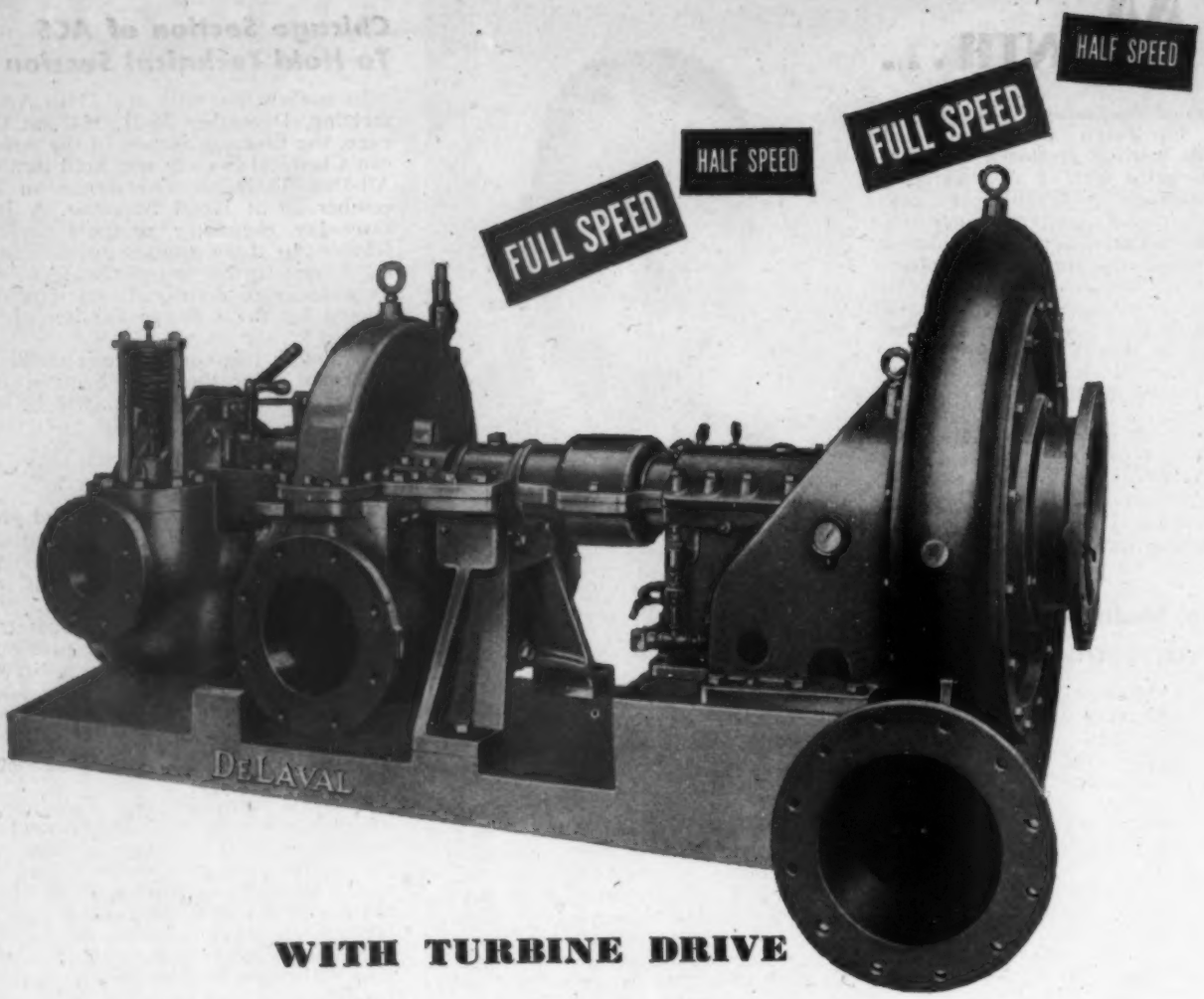
Concentration in ownership of world oil reserves has reached a point, he said, where a few companies can fix oil prices, declaring "the power to fix prices is the power to destroy because the very foundations of society are undermined when concentrated economic power fixes prices to serve its own purposes without regard for public responsibility."

Such concentration of economic power has been made possible by inadequate existing law but "those who have built up the modern collective industrial corporation are laying the basis for collective government," and "if we would avoid a planned economy enforced upon us by the managers of a collectivist state, then we must find a way to avoid the planned economy of the managers of the collectivist corporation."

O'Mahoney said that major oil companies own 81 percent of all U. S. oil reserves as compared with 65 percent in 1939. "The modern corporation" also controls the reserves in Latin America and in the Near East.

He agreed in connection with the independents' fight on the proposed Anglo-American oil treaty that "the union of the modern petroleum corporation with the government under the treaty would opearte to the disadvantage of the small producer."

O'Mahoney told the bar committee that there was a lack of comprehension of the basic fact that "the modern economy bequeathed to us by the engineers and the scientists is an economy of or-



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THE MONTH...

ganizations, for which the lawyers have not provided the necessary frame of harmony."

Russell Brown, general counsel of the Independent Petroleum Association of America, several days before had warned against the trend toward concentration in the oil industry, declaring that control of prices by a few large companies was discouraging domestic producers and squeezing domestic refiners and marketers. He referred to the "open collaboration" of a few large companies in their effort to obtain large petroleum resources outside the U. S., "the effect of which in part is that of weakening domestic producers, refiners and marketers."

Shell Studies Asphalt

A new laboratory devoted exclusively to the study of asphalt and its application has recently been established at Wood River, Ill., by Shell Oil Company, C. E. Davis, vice president, manufacturing, New York, has announced. "One of our main objectives is to isolate and correct common causes of road failure, but our over-all research program will aid greatly in improving asphalt for all types of applications, and determining many new uses for this material," Davis commented.

Skeen Joins Snell

John R. Skeen joined the staff of Foster D. Snell, Inc., consulting chemists and engineers, New York, on September 1 as account executive in charge of market research. Since 1945 Dr. Skeen has been principal chemical engineer in the business and industries division of the Bureau of Internal Revenue's Income Tax Unit, where he acted as consultant to the field divisions in the examination of claims of chemical companies for relief from excess profits taxes.

New Gulf Vice Presidents

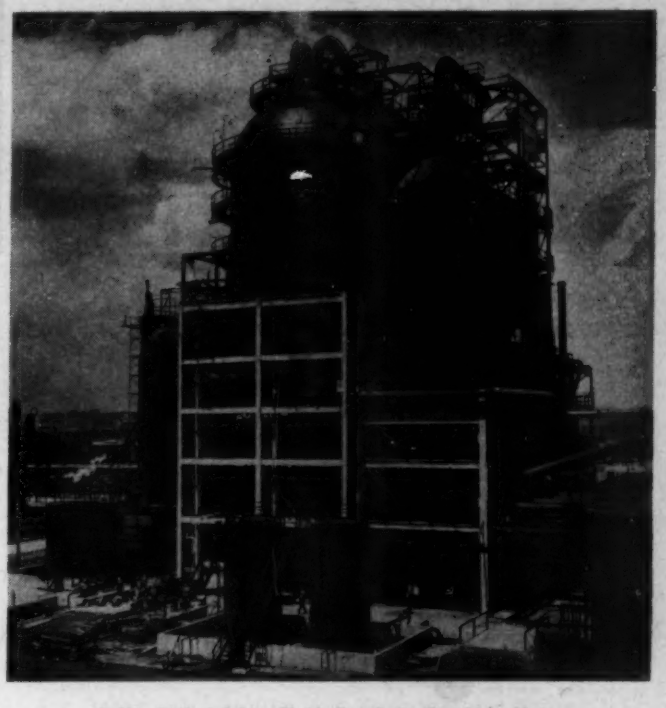
Two new vice presidents have been named by Gulf Refining Company and Gulf Oil Corporation as follows: R. M. Bartlett, with Gulf since 1923, manager of fuel oil sales, and H. P. Hobart, with Gulf since 1919, general manager of lubricating oil sales.

Arthur Little Additions

Arthur D. Little, Inc., Cambridge, Mass., industrial research organization, has announced several additions to its technical staff including:

Russell J. Bowen, master's degree in chemical engineering, M.I.T.; Robert W. Fabian, formerly engaged in governmental research at Wesleyan University; Thomas Hall, M.S. in organic chemistry, Tufts College; William V. Keary, chemical engineer formerly with Publicker Industries, Inc., Eddington, Pa.; Benjamin A. Lambert, chemical engineer previously with Polaroid Corporation, Cambridge, Mass.; Albert E. Mignone, mechanical engineer and formerly research director for the U. S. Naval Torpedo Station, Newport, R. I.; George E. Richter, electronics, engineer previously with Ruge-deForest, Cambridge, Mass.; Richard W. Tindal, economic analyst, formerly operating his own manufacturing business in Springfield, Mass.; and Elizabeth Thorogood, biologist formerly engaged in teaching.

Turn-Around Termed Most Successful



The Fluid catalytic cracking unit at the Philadelphia refinery of Gulf Oil Corporation shown above recently experienced its first turnaround after a planned initial run of nine months. Every major vessel was entered and inspected and most exchanger bundles were pulled. Despite the exacting tests made in the survey, "the unit was found in such excellent condition that the total number of man hours expended for preparation, inspection, cleaning and repair made this Gulf turn-around one of the best in Fluid unit history from a labor economy standpoint," according to The M. W. Kellogg Company which designed and constructed the unit.

Gulf's Philadelphia Fluid Catalytic-Cracking Unit

Technical Problems Topics Heard at Southwest Louisiana Institute Meet

By L. S. DANIELS, Editor

Southwest Louisiana Institute served as host at Lafayette, Louisiana, for an all day meeting on September 20 of the American Chemical Society's Southwest Louisiana Section. Although the occasion was a regular meeting of the section, invitations were extended to all society members in neighboring areas of Louisiana and Texas, and special efforts were made in the preparation of inspection tours at Southwestern and demonstrations for the visitors.

President Joel L. Fletcher of Southwestern spoke on the progress made by the school's chemical engineering department and on the economic importance of education in raising living standards and developing the resources of the state. He said that lack of education up to the maximum levels which can be effectively utilized by the individuals is far more costly to a state than is the cost of education.

R. W. Krebs, assistant director of Esso Laboratories, Baton Rouge, talked on "The Development of Synthetic Fuels from Natural Gas." Dr. Krebs discussed the reserves of liquid fuel which can be made available from our resources of natural gas, coal, and oil shale at varying gasoline price levels and presented simplified diagrams of some of the process equipment which will be utilized.

Panel discussions were conducted following the general assembly. E. W. Freeman of Cities Service Refining Corporation, Lake Charles, served as chairman for a group discussion of the topic "Industry's Expectation of the Technical this panel included J. E. Fenex, general Man." Representatives for industry on superintendent of Continental Oil Company's Lake Charles Refinery and James F. Newell, general manager of the Mathieson Alkali Works at Lake Charles; representative for colleges was Dr. K. M. Loughmiller of Southwest Louisiana Institute.

V. A. Kalichevsky, consulting chemist of Magnolia Petroleum Company, Beaumont, Texas, was chairman of a group which discussed petroleum chemicals, and heard a paper "Olefins in Petroleum Gases" by E. R. Smoley, of The Lummus Company, New York.

J. H. Stewart, Jr., Industrial Radiography Laboratory, Beaumont, was chairman of a group which considered recent developments in industrial inspection procedures. O. W. Olson, process engineer, and R. M. Brent, chief instrument engineer, The B. F. Goodrich Company, Lake Charles, gave a paper "Penetron and Its Uses," and an equipment demonstration. W. E. Barnes, production engineer, production research laboratory, Sun Oil Company, discussed "Probolog and Its Uses" and "Deep Hole Calipers," and gave a demonstration of equipment. J. H. Stewart talked on "Audiogage and Sperry Reflectogage," "Supersonic Reflectoscope," "Radiograph and X-Ray Inspection" and "New Spectographic Method of Analysis."

Arrangements for the day long meeting at Lafayette were made by officers

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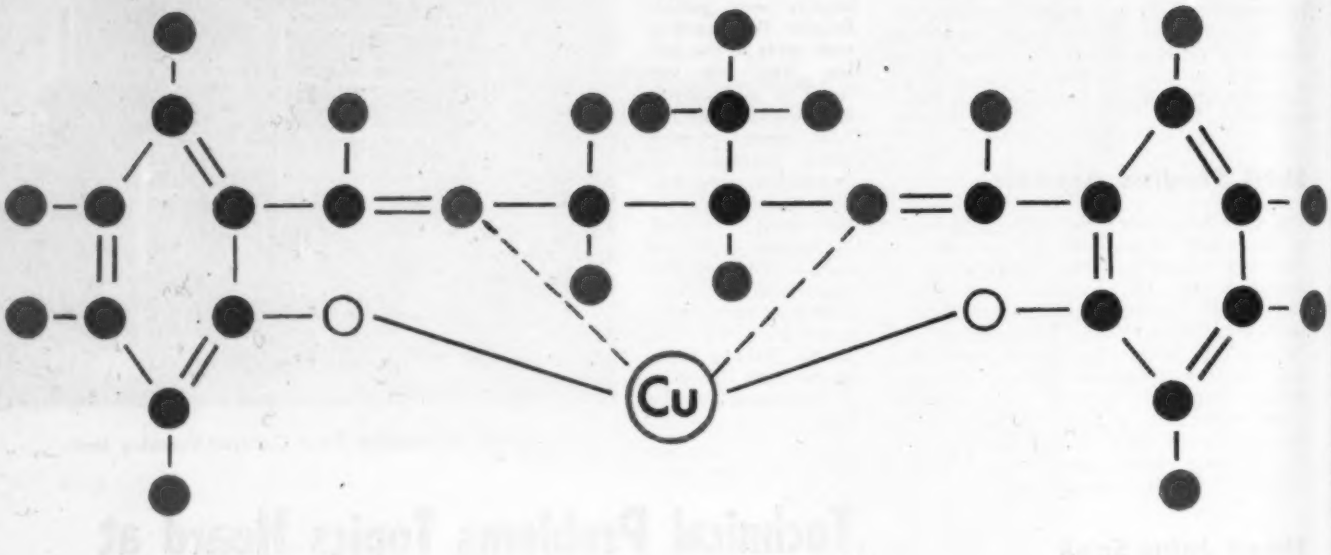

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THE MONTH...

and committee members of the Southwest Louisiana ACS Chapter, including W. A. Wilson, T. W. Kirby, R. W. Rice, E. G. Anderson, J. D. Fuller, R. A. Given, W. L. Hiller, E. C. Oden, F. W. Zurburg, and Miss Marie L. Comeux, and A. R. Rescorla, the section chairman who is chief chemist for Cities Service Refining Corporation, Lake Charles.

General Petroleum Plans Industrial Relations Unit

General Petroleum Corporation will start work immediately on the first unit of an industrial relations building at its Torrance refinery. The initial segment will contain 5000 square feet of floor space and cost approximately $100,000. Included will be a modern industrial hospital as well as complete industrial relations organization facilities.

H. E. Hanson Retires

H. E. Hanson, general manager of sales of Standard Oil Company (Indiana) and a member of the board of directors, has retired from both positions under the company annuity plan. He was succeeded in the sales position by R. F. Baity, assistant general manager of general sales. Joseph K. Roberts, general manager of research, was elected to the vacant seat on the board.

Allgower Is Treasurer

Standard Oil Company (Ohio) has named E. W. Allgower treasurer of the company. He has been with the company for more than 30 years, most recently as assistant treasurer.

Commercial Chemical Meets

Two important meetings of the Commercial Chemical Development Association have been announced by Dr. L. B. Hitchcock, president of the Association. Dr. Hitchcock, vice president of The Quaker Oats Company, stated that the Association is concerned with problems and marketing of new chemicals and problems of expanding the market for manufacturted chemicals. The fall meeting set for October 28 in Cleveland and a March, 1948, meet also is assured.

Symposium on pH Measure

Seven technical papers and discussion comprising the Symposium on pH Measurement are intended to present the latest theory and practice on colorimetric and potentiometric methods for making pH and closely related measurements. The Symposium was organized by ASTM Subcommittee XIII on Hydrogen Ion Determinations. Four broad topics are covered: a history of the field; a discussion of fundamentals and the broad theoretical basis for pH determinations; recent advances in the principal methods and techniques; and applications to particular fields.

This 86-page publication, heavy paper cover, can be obtained from ASTM, 1916 Race Street, Philadelphia 3, at $1.50 each.

Foster Wheeler Veterans

The Foster Wheeler 25-Year Club recently honored those with a quarter century or more of service with a day's outing in New York and Carteret, followed by a dinner. The club's membership exceeds 200 and the oldest member has been with the company for 50 years.

Refinery Division Meetings and Papers Scheduled at Annual Sessions of API

A full agenda of committee meetings and papers of interest to the Refining Division are scheduled for the Twenty-seventh annual meeting of the American Petroleum Institute, Stevens Hotel, Chicago, November 10-13.

A distinguished list of speakers headed by Secretary of Interior J. A. Krug is booked for appearance at the three general sessions. Among those who have accepted invitations for addresses are included:

B. Brewster Jennings, president of Socony-Vacuum Oil Company, Inc., "The International Petroleum Situation."

Bruce K. Brown, president of Pan American Petroleum Corporation, "Petroleum and Its Relations to National Defense."

Hiram M. Dow, chairman of the Interstate Oil Compact Commission, "The Conservation of Oil and Gas."

Walter S. Hallanan, president of Plymouth Oil Company, "Solving Petroleum-Industry Problems."

John M. Lovejoy, president Seaboard Oil Company, "Petroleum Industry Public Relations."

Henry J. Taylor, economist and journalist, "Looking Ahead at Home and Abroad."

At 10 a.m. Monday the Division of Refining Committee an Analytical Research will sponsor a symposium on evaluation and testing of cracking catalysts, with papers on the following papers planned:

"A Plant Control Test for Particle Size of Fluid Cracking Catalyst."

"Modification in the Roller Analysis for Determination of Particle-Size Distribution."

"Accurate Particle-Size Determination of Fluid Catalysts by Coordination of Roller Analysis and Microscopic Examination."

"Prediction of the Activity of Cracking Catalysts from Heat of Wetting."

"The Rapid Estimation of Surface Area of Cracking Catalysts by the Aromatic Adsorption Method."

"Relative Values of Aromatic Adsorption Indices and D + L Activity Tests."

"Simplified Method for Determination of Carbonaceous Deposits on Cracking Catalysts."

"Standard Laboratory Method for the Determination of Cracking Catalyst Activity."

"Determination of Activity and Selectivity of Cracking Catalyst."

"Bench-Scale Method for Determining Activity of Cracking Catalysts in Powdered Forms."

"Design and Operation of a Bench-Scale Automatic Catalyst-Aging Unit."

"Bench Testing and Evaluation of Fluid Cracking Catalysts."

"Small-Scale Laboratory Testing of Cracking Catalysts."

"Pilot-Plant Evaluation of Fluid Cracking Catalysts."

The Division of Refining's 10 a.m. session Tuesday will discuss sour crude processing with the following topics and speakers:

"Sour Crudes—Trends in Supply." Harold M. Smith, U. S. Bureau of Mines, Bartlesville, Okla.

"Sour Crudes—Some Processing Answers." M. J. Fowle and R. D. Bent, The Atlantic Refining Company, Philadelphia.

"Sour Crudes—Trends in Supply." Harold Q. Camp, Humble Oil & Refining Company, Houston.

Report of Division's Nominating Committee. A. H. Calderwood, Shell Oil Company, Inc., San Francisco, chairman.

Election of Members of the General Committee of the Division of Refining.

Committee sessions at Chicago include (chairmen shown when available):

Thursday, November 6, 9 a.m.—Special Subcommittee on Mill Hydrostatic Tests, P. A. Mills.

Friday, November 7, 10 a.m.—Subcommittee on Refinery Inspection Supervisors, F. L. Newcomb.

SATURDAY, NOVEMBER 8

9 a.m.—Manufacturers' Subcommittee on Refinery Valves and Fittings, W. P. Kliment.

10 a.m.—Subcommittee on Pressure Relieving Systems, E. O. Mattocks.

10 a.m.—Committee on Fire Protection Information, J. Willard Lord.

2 p.m.—Committee on Fire Protection Regulations, George F. Prussing.

2 p.m.—Subcommittee on Alloys for Furnaces, A. B. Bagsar.

MONDAY, NOVEMBER 10

10 a.m. — Subcommittee on Temperature Measurement, W. B. Ross.

10 a.m.—Committee on Disposal of Refinery Wastes, W. B. Hart.

10 a.m.—Lubrication Committee, H. P. Hobart.

11 a.m.—Committee on Petroleum Products.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1946:									
January 26	4,626	4,553	220,544	13,622	101,737	5,720	29,498	8,411	39,722
March 2	4,726	4,779	229,430	13,871	104,462	5,888	25,148	8,634	38,441
March 30	4,425	4,684	224,994	13,896	104,715	5,337	28,240	8,738	37,746
April 27	4,672	4,685	224,443	14,228	99,631	5,568	30,466	9,204	39,404
May 25	4,759	4,857	222,214	14,322	95,769	5,463	32,973	8,908	43,338
June 29	4,957	4,854	223,883	14,500	92,333	5,325	37,762	8,828	46,447
July 27	4,926	4,896	223,756	14,535	88,626	5,817	44,316	8,217	49,517
August 31	4,833	4,901	225,672	15,405	86,813	5,374	53,858	8,357	53,037
September 28	4,778	4,829	221,903	14,538	85,854	5,450	57,903	8,158	56,914
October 26	4,730	4,758	221,184	14,863	84,623	5,710	65,499	7,728	60,872
November 30	4,795	4,707	225,119	15,145	88,371	5,228	66,062	7,672	58,647
December 28	4,713	4,968	226,111	15,604	93,126	5,931	58,941	8,181	53,427
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,357	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	8,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,876	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777

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GATX GENERAL AMERICAN

THE MONTH . . .

2 p.m.—Subcommittee on Refinery Valves, Homer G. Reed.
2 p.m.—Subcommittee on Corrosion, M. S. Northup.
2 p.m.—Correlating Committee on Measuring, Sampling and Testing Crude Oil, E. L. Adams.

TUESDAY, NOVEMBER 11

9 a.m.—Advisory Committee on Fundamental Research on Composition and Properties of Petroleum, W. J. Sweeney.
9 a.m.—Subcommittee on Speed Reducers, E. N. Kemler.
10 a.m.—Committee on Disposal of Refinery Wastes, W. B. Hart.
2 p.m.—Committee on Refinery Equipment, Bonner H. Barnes.
2 p.m.—Committee on Training in Refining, Harry D. Kolb.

WEDNESDAY, NOVEMBER 12

10 a.m.—Committee on Disposal of Refinery Wastes, W. B. Hart.
10 a.m.—General Committee, Division of Refining, Robert E. Wilson.
Undated meetings include:
10 a.m.—Subcommittee on Unfired Pressure Vessels, Walter Samans.
10 a.m.—Central Committee on Fire Protection, C. H. Bunn, Jr.

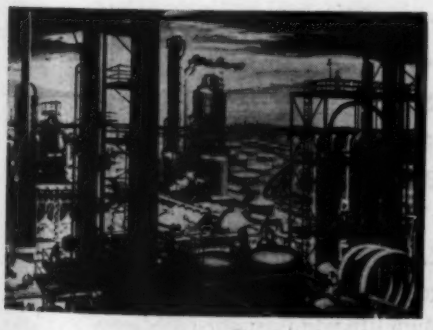
Arabian American Elects Brougham Vice President

Arabian American Oil Company has announced election of Robert I. Brougham as its financial vice president. He was formerly assistant treasurer of Standard-Vacuum Oil Company, treasurer of Creole Petroleum Corporation, and more recently foreign exchange manager of Standard Oil Company (New Jersey).

Crude for Paulsboro Plant from Venezuela

Crude oil from Socony-Vacuum Oil Company's wells in the state of Anzoategue, eastern Venezuela, will come to its refinery at Paulsboro, N. J. The crude is being moved through the company's new 12-inch, 103-mile pipeline.

"How" of a Refinery



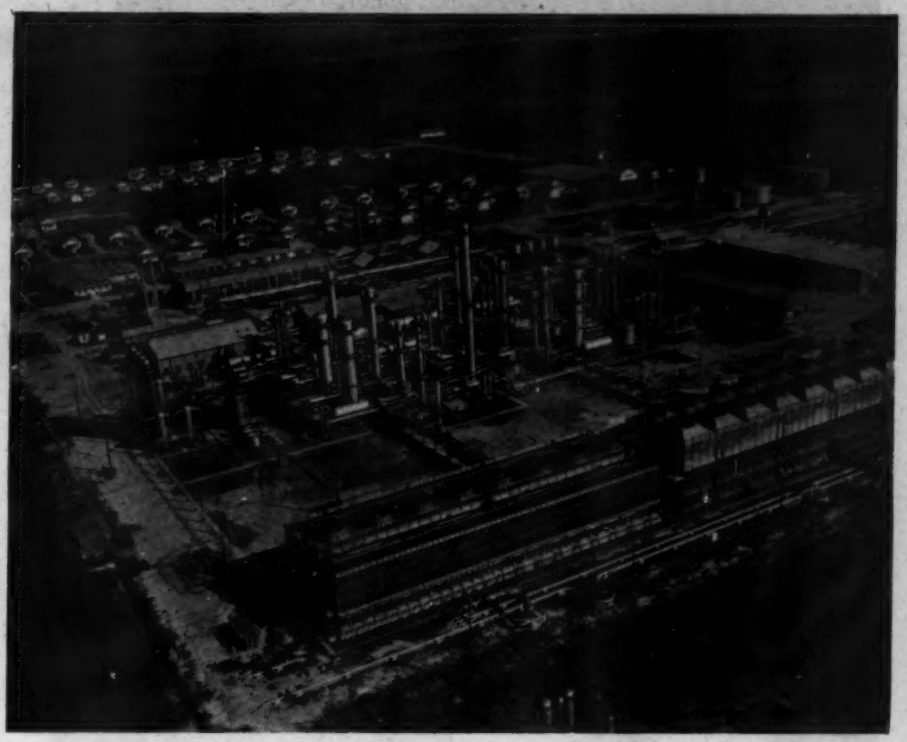
Armstrong Cork's Refinery Painting

THE operation of transforming crude oil into various products is briefly explained and illustrated in an Armstrong Cork Company advertisement entitled "How an Oil Refinery Operates" in a recent issue of *The Saturday Evening Post*. The presentation was prepared by Armstrong's Building Materials Division in collaboration with the American Petroleum Institute.

One of the features of the advertisement is the painting of a typical refinery, reproduced above, and its accompanying flow chart.

Offered free is a 22 x 23-inch enlargement of the refinery painting in full color ready for framing. Address 4709 Marietta Avenue, Lancaster, Pa.

Humble's Cycling Plant Expansion Announced



Airview of Katy, Texas, Cycling Plant of Humble Oil & Refining Company

Humble to Spend $6,860,000 on Katy Plant

An expenditure of $6,860,000 has been announced by Humble Oil & Refining Company for additions to the Katy cycling plant in northwest Harris County, Texas. The increased efficiency of the plant will be to obtain a higher recovery of the liquid products contained in the wet gases produced from the Katy field. Contract for the additions has been let to Stearns-Roger Manufacturing Company of Denver, Colorado.

According to the announcement: "The present production of propane, ethane, and butane, totaling approximately 5500 barrels daily, will be increased by slightly more than 5000 barrels daily, or perhaps nearly doubling the present production of these materials. The cost of the new absorption facilities required to obtain the increased efficiency and recovery is estimated at $6,860,000."

The plant is presently producing between 14,000 and 15,000 barrels daily of all products, including ethane, propane, and butane, on which production is to be increased. The total daily output of the plant with these increases will be about 18,000 to 19,000 barrels.

Approximately 450 million cubic feet of gas daily is processed in the plant at the present time, of which some 400 million cubic feet is injected into the producing formations, and the remaining 50 million cubic feet sold for fuel.

Built shortly before the war, the plant is reported the largest of its kind in the world.

Fin and Coil Engineering Data Book Published

An engineering data book providing fundamentals of pipe and fin coil calculation has been published by The Rempe Company, 340 North Sacramento Boulevard, Chicago 12. Compiled by engineers especially for draftsmen and designers the book aims to provide complete information necessary for laying out pipe and fin coils for heating and cooling application.

It treats heat transfer "K" factors for all ranges of heating and cooling from minus 60 to plus 350° F.; gives recommended air velocities and fin spacing for fin coils; shows how to calculate and design pipe and fin coils for all generally encountered heating and cooling loads.

Besides reference and design sections for both pipe and fin coils, the book treats such subjects as inspecting, testing and finishing of coils, calculation of heating and cooling coils, methods of computing fin coil surfaces, etc.

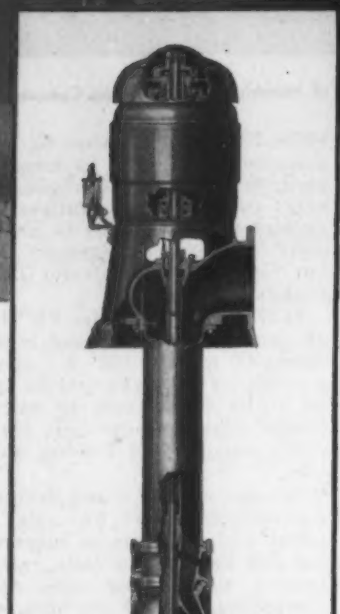
Jet Fuel Studies Progress Are Announced by Shell

An improved method of determining the efficiency of jet engine performance has recently been developed at the jet engine laboratory of Shell Oil Company, Inc., at Wood River, Ill. C. E. Davis, vice president of manufacturing, added that laboratory technicians had also discovered the major causes of troublesome carbon deposition in jet engines.

Efficiency of jet engines is measured at Wood River by a new method of analyzing exhaust gases, Davis explained. The exact composition of fuel that enters the engine is known; hence, analysis of a sample of exhaust gas determines how efficiently the engine has used its fuel.

Jet engines have presented special problems, however, because only an infinitesimal quantity of unburned fuel remains in the exhaust, mixed with tre-

Cooling Tower Water Service Installation with PACIFIC Type CT Vertical Pumps driven by electric motors—Courtesy Phillips Petroleum Company.



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THE MONTH...

mendous quantities of air. Shell scientists, therefore, have had to perfect new methods of quantitative gas analysis.

As an additional refinement of the test procedure, the laboratory has devised a means for running continuous tests of exhaust gases, thus obtaining a constant record of engine performance. The new analytical techniques have been made available to others interested in jet fuels.

Concerning the formation of carbon deposits in jet engines, Davis said that under improper conditions of jet fuel use, so much carbon is deposited that the airplane engines must be overhauled every five to ten hours. Laboratory tests at Wood River reveal that chief factors affecting this excessive carbon deposition are: a) fuel composition; b) fuel volatility; c) intake temperature of the fuel mixture into the jet engine; d) method of introducing fuel; and e) conformation of the combustion chamber of the engine. Experiments indicate that "carboning-up" of the engines can be reduced by altering these factors.

Diesel Engine Makers Continue Work in Schools

Makers of Diesel engine parts and accessories have joined makers of the engines themselves in a five-year educational program "designed to help colleges and universities turn out a better type of engineer," according to E. J. Schwanhausser, vice president of Worthington Pump & Machinery Corporation, who heads the Diesel Engine Manufacturers Association.

The plan is a development of three years of educational work directed by the association. This included extensive school visitation and discovery of their acute needs. Laboratory equipment particularly has been improved by these contacts and instruction has improved through short courses, etc.

George H. Amberg, recently added to the association's staff, will devote his full time to educational work. A parts makers panel at one of the top-ranking universities is included in the program, and a continuous effort will be made to improve Diesel engine trade schools.

Distillation Bibliography

An original German work, "Die grundlegenden Arbeiten uber Theorie, Apparate sowie Verfahren der Destillation und Rektifikation", issued in 1944 by VDI-Verlag GMBH, Berlin NW7, Germany, has been published in this country by Hobart Publishing Company, Washington 15, D. C. under authority and license of the Attorney General. The work, which comprises a bibliography of distillation and related technical literature for the years 1920 to 1944, is in its original form with the exception of the foreword which has been translated into English. It was the stated object of the editors, H. Stage and Gg. R. Schultze, to provide an adequate working tool for application to special distillation problems, so that any preliminary work reported in the literature can be profitably utilized.

Petroleum Chemistry Abstracts

ACS Division Sessions, New York, September 15-19

ABSTRACTS of the papers presented in New York last month when the Division of Petroleum Chemistry of the American Chemical Society held sessions on production of synthesis gas (joint with the Division of Gas and Fuel Chemistry) and a symposium on purity and identity of organic compounds (joint with Divisions of Analytical and Micro, Biological, Organic, and Physical and Inorganic Chemistry are presented below.

The Swedish Shale Oil Industry

GUSTAV EGLOFF, *Universal Oil Products Company, Chicago.*

Sweden has large shale deposits which produce about 15 gallons of oil per ton by retorting. During the war as a result of an oil and coal shortage the Swedish government invested more than $25 million in a new oil shale industry based upon four different processes, two of which are distinctly Swedish inventions, and the others are modifications of methods developed in Scotland and Esthonia. The four processes are the Bergh, the Rockesholm (modified Scottish Pumpherston type), the "Industrial Method" (modified Estonian), and the Ljungstrom (oil distilled from shale *in sit.* These processes produce at the yearly rate of 225,000 barrels of gasoline, 32,000 barrels of kerosine, and 325,000 barrels of fuel oil with an installation going in to recover 160,000 barrels of liquefied propane and butanes from the gases. Pure sulfur is produced from the hydrogen sulfide present in the gases at the rate of 22,000 tons yearly. There are also a thousand tons of ammonium sulfate made yearly. Chemical derivatives such as ethyl alcohol, glycols, and halogen compounds are to be produced from the olefins present in the gases. From the limestone derived from the oil shale crushing, about 60,000 tons of lime are produced yearly. Plans are under way to produce uranium oxide, alumina, potash, bricks, construction material, and insulating material (rock wool) from the spent shale.

High-Pressure Laboratory Flow Apparatus

V. N. IPATIEFF, G. S. MONROE, and L. E. FISCHER, *Universal Oil Products Company, Riverside, Ill.*

This paper describes a high-pressure laboratory flow plant designed to process, thermally or catalytically, gaseous or liquid materials, or combinations of both, at pressures up to 13,000 psi and at temperatures up to 565°C. The apparatus as described has given satisfactory results in high-pressure reactions, such as the synthesis of methanol from carbon dioxide and hydrogen and the conversion of benzene and benzenemethane into toluence. Included are two photographs of the apparatus, one showing the barricade doors open, and the other showing them closed; a flow diagram, and a sectional elevation view of the furnace-catalyst tube assembly.

Investigation of Deposition and Oil Deterioration Phenomena by Means of a Motored Engine.

H. DIAMOND, H. C. KENNEDY, and R. G. LARSEN.

In a fundamental study of the factors influencing upper-cylinder deposition phenomena, a test has been developed in which an engine is motored while the jacket is heated; ignition, fuel, and valve systems are eliminated and the atmosphere inside may be of any desired gas. It was demonstrated that deposits may be formed which arise solely from the lubricant through oxidation. Preoxidation of an oil at moderate temperatures affects its subsequent behavior at higher temperatures. The action of some typical additives in the motored engine is roughly similar to that in a regular engine. Among several possible exhaust and blow-by gas components examined, only sulfur trioxide produced an appreciable effect.

The Pyrolysis of Pentene-2 and Trimethylethylene in the Presence of Steam

H. J. HEPP and F. E. FREY.

Pentene-2 and trimethylethylene were cracked in quartz by a flow method at temperatures in the range of 778° to 850°C. in the presence of varying amounts of steam.

Pentene-2 cracked to yield butadiene as a major product, the yield varying from 33 to 55 moles per 100 mols of pentene-2 reacted, depending upon conversion, temperature, and dilution. Pentadiene was also formed in amounts of the order of 10 moles per 100 mols reacted. Ethane and butene appeared to be primary reaction products along with butadiene, ethylene, and propylene.

Trimethylethylene cracked to yield isoprene as a major product, the best yield obtained being 38.3 moles per 100 mols reacted. Butadiene yields in the region of 10 moles per 100 mols reacted were also obtained. Butenes were formed in substantial amounts of the order of 40 moles per 100 mols of trimethylethylene reacted.

Trimethylethylene is more stable than pentene-2, the ratio of the first-order reaction velocity constants at 800°C. being about 5. The reaction velocity constant of pentene-2 is low in the region of 0.1 to 0.2 atmosphere partial pressure, indicating a marked pressure effect in this region.

Physical Properties and Characteristics of Polyform Distillate

W. C. OFFUTT, M. C. FOGLE and H. BEUTHER, *Gulf Research & Development Company, Pittsburgh.*

Many of the physical properties and characteristics of Polyform distillate can be attributed to the operating conditions of the Polyform process—high pressures, high temperatures, and cracking in the presence of recirculated gases (C_3 and C_4

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Ernest R. Hanson, long in the field of plastics through his connections with Halowax Corporation and Bakelite Corporation, has joined the staff of Foster D. Snell, Inc., consulting chemists and engineers, New York, to head up research and development in the field of plastics and rubber.

Dr. Hanson holds nine U. S. patents for his inventions in the plastics field and is the author of a number of scientific papers in the field of organic chemistry.

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hydrocarbons). Polyform distillates have high over-all volatility; they contain more low-boiling and less high-boiling material than most gasolines from other refining processes. Polyform distillates are rich in low-boiling olefins, lean in high-boiling olefins, and rich in aromatics. They have high octane numbers with excellent blending values and good road performance. In addition, Polyform distillate can be catalytically treated to produce a good aviation base stock. Polyform distillate is compared with straight-run, thermally cracked, and catalytically cracked gasolines with respect to precision chemical analysis and actual road performance.

Production of Xylidines by High-Pressure Hydrogenation. I. Process Development

C. L. BROWN, *Research and Development Dept., Standard Oil Development Company, Elizabeth, N. J.*, W. M. SMITH, *Esso Laboratories, Standard Oil Company of New Jersey, (Louisiana Division), Baton Rouge, La.*, and W. G. SCHARMANN, *Esso Laboratories, Standard Oil Development Company, Development Division, Elizabeth.*

Aromatic amines may be used as blending agents in aviation gasolines to extend supplies or to provide increased power output under conditions of rich mixture operation in aircraft engines. During World II, xylidines were produced for a limited period at the Louisiana Division of the Standard Oil Company of New Jersey. The process used involved the high-pressure hydrogenation of nitroxylenes, produced at various Ordnance Works in the United States by the mononitration of xylenes obtained mainly as a by-product in the production of synthetic toluene from petroleum by the hydroforming process. Overall yields of finished specification xylidines of 85 to 90 percent of the theoretical were obtained.

Production of Xylidines by High-Pressure Hydrogenation. II. Quality and Performance Characteristics

J. F. KUNC, JR., and W. C. HOWELL, JR., *Esso Laboratories, Research Division, Standard Oil Development Company, Elizabeth N. J.*, and C. E. STARR, JR., *Esso Laboratories, Standard Oil Company of New Jersey, (Louisiana Division), Baton Rouge.*

The projected use of xylidines to extend supplies of aviation gasoline during World War II led to the application of the high-pressure hydrogenation process as one phase of a government-industry cooperative project for their manufacture. Evaluation of xylidines produced from the high-pressure hydrogenation process showed them to be similar to other xylidines produced in the joint effort with respect to imparting markedly improved rich-mixture antiknock performance to aviation gasoline blends. Their relatively poor color stability, however, necessitated improvement by treating methods. Xylidines gasoline blends have satisfactory freezing point, water solubility, and gum stability characteristics, although they are reactive toward synthetic rubber membranes.

Mercaptan Formation in Acid Treatment of Pressure Distillate

C. R. WILKE, *University of California Berkeley, Calif.* and WILLIAM JAMES WRIDE, *State College of Washington, Pullman, Wash. (present address: Department of Chemical Engineering, Iowa State College, Ames, Iowa.)*

Experiments are described showing the formation of appreciable quantities of mercaptans in the acid treatment of pressure distillate containing hydrogen sulfide. The data indicate the addition of hydrogen sulfide to olefins with the acid acting as a catalyst. Mercaptan formation as high as 969 mg. of sulphur per liter occurred in pressure distillate initially containing 1430 mg. of hydrogen sulfide per liter during treatment with 5 pounds of 97.4 percent sulfuric acid per barrel. Formation of disulfides was also observed. Similar results were obtained with caprylene-Skellysolve mixtures. The effects of temperature, acid strength, and acid quantity were studied over a range of conditions used in industrial practice.

The Catalytic Addition of Paraffins to Acetylenic Hydrocarbons

CARL B. LINN and ARISTID V. GROSSE.

The catalyzed interaction of ethyne or propyne with certain paraffins was studied at temperatures near atmospheric and at atmospheric and higher pressures. Ethyne reacted with isobutane or *n*-butane, but not with propane, in the presence of aluminum chloride (+HCl) at superatmospheric pressure; the product was composed of paraffins boiling in the gasoline range. Although ethyne did not react with isobutane in the presence of boron fluoride (+HF), propyne and isobutane reacted to give a paraffinic alkylate when that catalyst was used. Some free energy calculations were made using data recently released by the Bureau of Standards.

Solutions of Aluminum Chloride in Nitroparaffins as Catalysts for Hydrocarbon Reactions

LOUIS SCHMERLING, *Universal Oil Products Company, Riverside, Ill.*

Aluminum chloride dissolves readily in nitromethane, nitroethane, and the two nitropropanes yielding solutions which, in contrast to those in alcohols, ethers, and ketones, are catalytically active. The active component of the solution is the addition complex, $AlCl_3 \cdot RNO_2$.

The nitroparaffin solutions of aluminum chloride are miscible with aromatic hydrocarbons; the nitroparaffins thus are solutizers for the metal chloride in the hydrocarbon. Homogeneous phase alkylation of benzene, for example, may be accomplished by contacting the clear solution with an olefin or alkyl halide. Should it be desired to carry out the alkylation in a two-phase system in order to permit the recycling of the catalyst, the catalyst layer may be salted out by adding sodium chloride.

The solutions of aluminum chloride in the nitroparaffins may also be used for the alkylation of isoparaffins with olefins. The solutions are not soluble in paraffins and are available for recycling. Higher reaction temperatures are necessary than are used with unmodified aluminum chloride. Data for the alkylation of isobutane with propene will be discussed.

When isopropyl chloride is contacted with isobutane in the presence of unmodified aluminum chloride, the principal reaction is reduction of the alkyl chloride to propane. If, on the other hand, a solution of aluminum chloride in nitromethane is used as catalyst, reduction of the isopropyl chloride is markedly decreased and alkylation of isobutane to heptane occurs.

The nitroparaffin solutions of aluminum chloride effected virtually no isomerization of *n*-pentane or methylcyclopentane.

Effect of Various Additives in the Isomerization of *n*-Pentane

JULIAN M. MAVITY, HERMAN PINES, RICHARD C. WACKHER and JOHN A. BROOKS, *Universal Oil Products Company, Riverside, Ill.*

Isomerization of *n*-pentane to isopentane in the presence of aluminum chloride-hydrogenchloride catalyst is normally accompanied by considerable cleavage and disproportionation. Results of experiments are reported in which this reaction was modified by introducing various organic additives with the feed. Among those found to be most effective for repressing side reactions were certain napthenic and aromatic hydrocarbons. Straight-run C_6 fractions containing small or moderate concentrations of benzene or C_6 napthenes also proved satisfactory. Some aromatic derivatives—e.g., chlorobenzene and diphenyl ether—showed similar properties.

The concentration of a given additive must be carefully controlled to obtain the optimum effect, since an excess was found to repress isomerization as well as the side reactions. Thus while 5 to 10 volume percent of cyclohexane gave good results, the optimum concentration of benzene was about 0.25 to 0.5 volume percent.

Both batch tests and continuous runs of the aluminum chloride pickup type were made. In the latter type of operation the additive has the additional function of repressing sludge formation in the aluminum chloride supply zone. The mechanism of the reactions is discussed.

The Combustion of Motor Fuels

CECIL E. BOORD.

When the peroxidation mechanism of Walsh is rigidly applied to iso-octane the initial oxidative degradation products are acetone and formaldehyde. These same principles can be applied to any individual hydrocarbon used as a motor fuel. Such an application would seem to imply that those paraffin hydrocarbons which yield chiefly acetone as the initial oxidative degradation products have high engine characteristics and that those which yield chiefly formaldehyde as the initial product have a pronounced tendency to knock.

A concomitant or alternative implication is that those hydrocarbons which have as a part of their molecular structure very reactive tertiary hydrogen atoms have high engine characteristics. Conversely those hydrocarbons from which active hydrogen has been excluded have lower critical compression ratios.

Examples are drawn from the engine data tables of API-RP 45 to confirm or disprove the above hypothesis. In general it is found that when the number of active hydrogen atoms is increased the critical compression ratios rise. When these active hydrogens are removed the critical compression ratios fall. Methyl groups are shown to be activating groups. It is suggested that tertiary butyl groups (and other similar tertiary groups) are highly activating.

The double bonds in olefins through the well-known allyl effect also produce activation and increase the critical compression ratio. When, as in the case of converting 2,3-dimethylbutane into 2,3-dimethyl-2-butene, the formation of the olefin removes the two very reactive tertiary hydrogen atoms the critical compression ratio falls. Correlation of engine data with molecular structure shows the same principle to be applicable in the paraffin, olefin, cycloparaffin, and aromatic series.

Gaps in Physical Constants Data for Hydrocarbons

NANCY CORBIN, MARY ALEXANDER, and GUSTAV EGLOFF, *Universal Oil Products Company, Chicago.*

The importance of correlations between physical properties and structure of hydrocarbons is stressed. The quality and quantity of data needed for such correlations are discussed, and the available data analyzed. The analysis shows the percentage of known alkanes, unsaturated aliphatics, alicyclics, mononuclear aromatics, and polynuclear aromatics for which each of four physical constants (melting point, boiling point, density, and refractive index) has

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been recorded. Further analysis shows the percentage of compounds in each class for which the data were adequate to calculate a "best value." A comparison of correlations covering the different classes of hydrocarbons shows that the quality and quantity of data are reflected in correlations. Suggestions are made for further research on physical constants.

An Electrometric Method for the Determination of Bromine Addition Numbers

H. D. DuBOIS and D. A. SKOOG, *California Research Corporation, Richmond.*

An electrometric method for the determination of bromine addition numbers has been developed which is particularly suited for routine work. The procedure involves direct titration with the stable potassium bromide-bromate reagent. A catalyst is used to increase the reaction rate, and cooling is used to reduce substitution to a minimum. The method is believed to have a number of advantages: 1) only a single, stable, standard reagent is used; 2) the presence of dark-colored materials causes no interference; 3) substitution is reduced to a minimum, and 4) the method is rapid and particularly suited for routine analyses.

Measurement of Heat of Combustion of Volatile Hydrocarbons. A New Liquid Sample Holder for Routine or Research Measurements

R. L. LeTOURNEAU and ROBERT MATTESON, *California Research Corporation, Richmond.*

A new sample holder is described for holding low-boiling liquid fuels in determining the heat of combustion. It has advantages over existing techniques for routine measurements and is suitable for research measurements. Typical results are given for pure hydrocarbons and production grade motor and aviation fuels. Isopentane is securely held at 25°C. only 3°C. below its boiling point.

Purification, Purity, and Freezing Points of n-Decane, 4-Alkylcyclopentanes, 9-Alkylcyclohexanes, 2-Monoolefins, 1,2-Butadiene, and 2-Butyne of the API-Standard and API-NBS Series

ANTON J. STREIFF, EVELYN T. MURPHY, JANICE C. ZIMMERMAN, LAUREL F. SOULE, VINCENT A. SEDLAK, CHARLES B. WILLINGHAM, and FREDERICK D. ROSSINI, *American Petroleum Institute Research Project 6, National Bureau of Standards, Washington, D. C.*

This report describes the purfication and determination of freezing points and purity of the following 18 hydrocarbons of the API-Standard and API-NBS series:

Paraffins	Alkylcyclopentanes
n-Decane	Cyclopentane
	1-Methyl-1-ethylcyclopentane
	cis-1-Methyl-2-ethylcyclopentane
	Isobutylcyclopentane

Alkylcyclohexanes	Monoolefins
cis-1,3-Dimethylcyclohexane	3,3-Dimethyl-1-butene
trans-1,3-Dimethylcyclohexane	1-Octene
n-Propylcyclohexane	*Diolefins*
Isopropylcyclohexane	1,2-Butadiene
1,1,3-Trimethylcyclohexane	*Acetylenes*
n-Butylcyclohexane	2-Butyne
Isobutylcyclohexane	
sec-Butylcyclohexane	
tert-Butylcyclohexane	

Correlations of the Properties of Alkylbenzenes

ALFRED W. FRANCIS, *Socony-Vacuum Laboratories, Research and Development Department, Paulsboro, N. J.*

Using a compilation which includes 367 known alkylbenzenes the densities, refractive indices, boiling points, and melting points are correlated by simple algebraic and graphical means, permitting the calculation of the first three properties for any alkylbenzene, and melting points for a few of them.

Equations are as follows, where n is the number of carbon atoms, a is the number of pairs of adjacent alkyl groups, and t is one for mono-*tert*-alkylbenzenes and zero for other aromatics:

for density

$$d_4^{20} = 0.850 + 0.12/n\ (1 + t + a)$$

for relation between density and refractive index

$$d_4^{20} - 0.854 = 27\ (n_D^{20} - 1.475)^2$$

for boiling point of *n*-alkylbenzenes

$$\text{b.p.} = 18n + 21 - 18/n^2$$

(similar equations for boiling point of other alkylbenzenes)

$$\text{m.p.} = 19n - 0.3\,n^2 - 247$$

for melting point of normal and several other classes of alkylbenzenes.

The Isolation and Physical Properties of the Diisopropylbenzenes

F. W. MELPOLDER, J. E. WOODBRIDGE, and C. E. HEADINGTON.

The three isomeric diisopropylbenzenes in purities of better than 99 percent were isolated from a high-boiling fraction produced by a commercial process for making cumene. A description is given of the method of separation employing distillation, sulfonation, fractional crystallization, and adsorption and the more important physical properties are listed. Infrared, ultraviolet, and mass spectra are given, the former confirming the chemical evidence of the structure of the compounds isolated.

Determination of Asphaltenes, Oils, and Resins in Asphalt

RETHEL L. HUBBARD and K. E. STANFIELD, *Bureau of Mines, Laramie, Wyo.*

A method is described for the Quantitative determination of the three groups of constituents—asphaltenes, oils, and resins—in petroleum and native asphalts. The asphaltene (benzene-soluble, pentane-insoluble) fraction is obtained by extracting the asphalt with normal pentane. The pentane-soluble portion is further fractionated by adsorption on anhydrous alumina and extraction first with pentane to obtain the oil fraction and then with a methanol-benzene solution to obtain the resin fraction. Unlike most proposed methods, the three asphalt constituents are recovered and may be used for further study. A complete analysis can be made in one eight-hour day after the sample has been dispersed in pentane and allowed to stand approximately 12 hours or overnight.

Chemical Analysis of Refinery C_5 Hydrocarbon Fractions

RICHARD F. ROBEY and HERBERT K. WIESE, *Esso Laboratories, Standard Oil Development, Elizabeth, N. J.*

After precise blending of the C_5 ("pentane cut") vapors with an inert gas it is possible to employ established rapid and accurate gas analytical methods for the determination of conjugated diolefins, tertiary mono-olefins, total unsaturated hydrocarbons, and total saturated hydrocarbons. Detailed consideration is given the analysis and stability of samples containing the individual diolefins, isoprene, cyclopentadiene, and *cis*-and *trans*-piperylenes. A new colorimetric method specific for isoprene employing mercuric acetate reagent is described. By applying most of the above methods in an organized scheme to predetermined subfractions obtained in superfractionation it is possible to define the composition of cracked fractions in terms of individual major components: neopentane, isopropyl ethylene, isopentane, 1-pentene, 2-methyl-1-butene, isoprene, *n*-pentane, 2-pentenes, trimethylethylene, cyclopentadiene, *trans*-piperylene, *cis*-piperylene, cyclopentene, and cyclopentane.

Mass Spectrometer—Hydrochlorination Analysis of the Butenes

F. W. MELPOLDER and R. A. BROWN.

An improved mass spectrometer method for analyzing the C_4 fraction is described wherein the isobutylene is first reacted with anhydrous hydrogen chloride and the reaction mixture then charged to the spectrometer. The resulting tertbutyl chloride in the mass spectrum makes it possible to determine isobutylene more accurately. It also serves to eliminate the interference of the isobutylene and thereby improve the resolution of 1-and 2-butene. Data are included on the analysis of synthetic mixtures as well as mass spectra of all the components.

Adsorption Studies of a Silica Gel and a Gel-Type Catalyst

ROBERT A. VAN NORDSTRAND, WILLIAM E. KREGER, and HERMAN E. RIES, JR., *Research & Development Dept., Sinclair Refining Company, East Chicago, Ind.*

The structure and structural changes of a silica gel and a cracking catalyst are investigated using nitrogen adsorption-desorption isotherms. Both solids are sintered stepwise in vacuo. The isotherm changes on sintering indicate destruction of pores but no change in average pore size or shape. However, the catalytic cracking process apparently causes an increase in average pore size. Grinding the catalyst results in important modifications of the isotherm. Changes in the high relative pressure range indicate fragmentation of the gel. The simultaneous loss of "surface area" suggests that BET areas for gel-type solids may be too high.

Furfural as a Selective Solvent in Petroleum Refining

L. C. KEMP, JR., Director of Research; G. B. HAMILTON, and H. H. GROSS of The Texas Company.

Most motor oils on the market today are solvent refined and a substantial percentage of the oils have been refined in units in which furfural is employed as the selective solvent. Since the requirement of furfural for solvent refining operations has always been a substantial percentage of the furfural production, increased use of furfural for refining has resulted in decreased costs, which further encourages extension of the use of furfural for this and other purposes.

Research and development work, combined with a considerable backlog of experience derived from full scale commercial operations, has made possible the application of the furfural refining process to a wide range of stocks from heavy residual materials to light lubricating oil distillates.

Attention is being directed to the application of furfural refining to the upgrading of stocks in the diesel fuel boiling range. Indicated future demand for such materials is so great that it will be necessary to employ some processing which will improve the quality of stocks which would otherwise be unsatisfactory. By employing newly developed procedures it appears possible to solvent refine such materials as the cycle gas oil from catalytic cracking operations to produce high quality diesel fuel. Other stocks can be similarly processed to obtain good quality fuels. This development may well result in a further and substantial increase in the quantity of furfural required for solvent refining.

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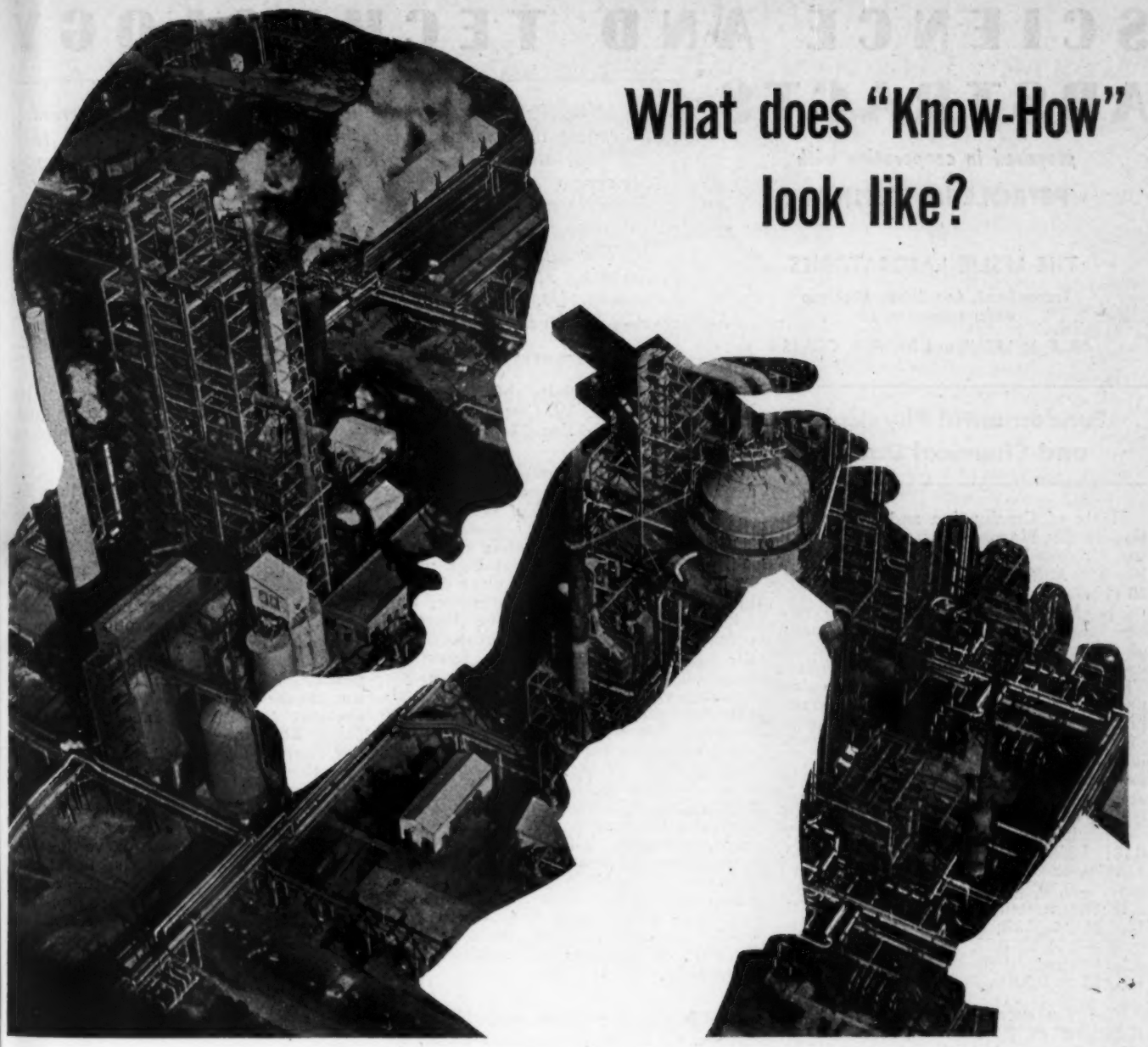

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

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Fundamental Physical and Chemical Data

Heats of Combustion and Isomerization of Six Nonanes. WALTER H. JOHNSON, EDWARD J. PROSEN AND FREDERICK D. ROSSINI, *J. Research Natl. Bur. Standards* **38** (1947) pp. 419-22.

The heats of isomerization of 6 nonanes were determined by measurement of the ratios of the heats of combustion in the liquid state of purified samples. The data were combined with the value previously reported for the heat of combustion of *n*-nonane to obtain the heats of combustion of the other five nonanes in the liquid state. The values for the heats of isomerization in the liquid state at 25° C. of *n*-nonane into the other nonanes, and the heats of combustion of the liquids are: *n*-nonane 0.00, 1463.80 ± 0.18; 3,3-diethylpentane —0.01 ± 0.33, 1463.79 ± 0.38; 2,2,3,3-tetramethylpentane —0.70 ± 0.31, 1463.10 ± 0.36; 2,2,3,4-tetramethylpentane —0.56 ± 0.22, 1463.24 ± 0.28; 2,2,4,4-tetramethylpentane —1.11 ± 0.25, 1462.69 ± 0.31; and 2,3,3,4-tetramethylpentane —0.62 ± 0.35; 1463.18 ± 0.39 kcal./mole, respectively.

The Pressure - Volume - Temperature Relations of 2,2,3,3-Tetramethylbutane. W. A. FELSING, A. M. CUELLER AND W. M. NEWTON, *Jour. Am. Chem. Soc.* **69** (947) pp. 1972-4.

The compressibility of highly purified 2,2,3,3-tetramethylbutane was determined between 110 and 270° C. at presures ranging from approximately 5 to 300 atmospheres. Pressures at the solid-liquid transition were determined at three temperatures, 110, 120 and 130°. The method of correlating liquid densities, as proposed by Watson, was applied to the data and the results were found to be quite satisfactory. The data secured in the work are presented in some detail in tabular and graphical form.

Quarter Circle Rule for Latent Heats. JOHN RAY HOPKINS, *Chem. Eng.* **54**:7 (1947) p. 111.

The author notes that there is a simple relationship between the temperature, molecular weight, and latent heat of vaporization. This is presented graphically. The curve for zero molecular weight is a quarter circle. The curve for an infinite molecular weight is a straight line. The family of curves in between follows the formula that is given in the article. A typical curve, as derived from the relationship between latent heat and temperature is given.

Therma l Conductivity of Gases at High Pressures. E. W. COMINGS AND M. F. NATHAN, *Ind. and Eng. Chem.* **39** (1947) pp. 964-70.

The authors note that the increasing use of high pressure processes has made knowledge of the effect of pressure on the physical properties of gases necessary. A method for predicting the thermal conductivity of a gas at high pressure is described. This requires only a knowledge of the critical pressure, the critical temperature, and the thermal conductivity at atmospheric pressure and the temperature in question. Enskog's equation of state and his two equations relating viscosity ratio to density and thermal conductivity ratio to density are used as a basis. The constants in all these equations are the same. These constants were evaluated from available P-V-T data and high pressure gas-viscosity data, and were then used to predict the thermal conductivity ratio at high pressures. The calculated ratios were arranged as a function of reduced pressure and reduced temperature. The effect of pressure on the Prandtl number was also determined. A graph is presented showing this ratio as a function of reduced pressure and reduced temperature.

Table of Azeotropes and Nonazeotropes. L. H. HORSLEY, *Anal. Chem.* **19** (1947) pp. 508-600.

The author presents a tabulation 90 pages in length in which are included the binary and ternary azeotropes and nonazeotropes as recorded in the literature. The tabulation is a collection that has been in use for several years, during which an effort was made to make it as complete and free from errors as possible. The table is arranged in two parts: (1) a table of binary systems and (2) a table of ternary systems. The system of classification followed is essentially that of *Chemical Abstracts*. A formula index at the end of the table lists under each component all the systems for which that compound is a component.

Graphical Method for Predicting Azeotropism and Effect of Pressure on Azeatropic Constants. L. H. HORSLEY, *Anal. Chem.* **19** (1947) pp. 603-9.

Charts are presented for 45 systems. These can be used for the determination of the azeotropic constants of the systems. A further use is for the estimating of the azeotropic boiling points and composition at pressures other than atmospheric. Although it is found that the agreement between predicted and experimental values is far from perfect, the procedure has served as a valuable guide in estimating the effect of pressure on azeotropic systems.

Graphical Method for Predicting Effect of Pressure on Azeotropic Systems. H. S. NUTTING AND L. H. HORSLEY, *Anal. Chem.* **19** (1947) pp. 602-3.

The authors report a rapid and easily applicable method for indicating the effect of pressure on the composition and boiling point of an azeotropic system. It was found that the vapor pressure curves of azeotropes are straight lines when plotted on a Cox chart, thus permitting the determination of the complete vapor pressure curve from data at two pressures. Since an azeotrope by definition has either a higher or lower vapor pressure than that of any of the components, the azeotropic vapor pressure curve will always lie above or below the curves of the components. If the azeotropic curve crosses either component curve the azeotropic vapor pressure is no longer greater or less than any of the components and the system becomes non-azeotropic at the point of intersection. On the other hand, if the azeotropic curve is parallel to the other curves the system will be azeotropic up to the critical pressure.

Chemical Compositions and Reactions

The Preparation of Hexachlorocyclopentadiene and Certain Derivatives. J. A. KRYNITASKY AND R. W. BOST, *Jour. Am. Chem. Soc.* **69** (1947) pp. 1918-20.

A new synthetic method for the preparation of hexachlorocyclopentadiene based on the pyrolysis of octachlorocyclopentene is described. Prins reaction has been extended to include a member of the alicyclic series. Three new compounds derived from hexachlorocyclopentadiene were synthesized. Physical properties of these substances are given as well as those of some of their intermediates.

Investigations on the Stereoisomerism of Unsaturated Compounds. VIII. The Catalytic Hydrogenation of Butadiene. WILLIAM G. YOUNG, RICHARD L. MEIER, JEROME VINOGRAD, HOWARD BOLLINGER, LOUIS KAPLAN AND SEYMOUR L. LINDEN, *Jour. Am. Chem. Soc.* **69** (1947) pp. 2046-50.

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presence of several common low pressure catalysts. These were found to exhibit a high degree of selectivity permitting the isolation in certain cases of high yields of dihydro-addition products. The dihydro products (butenes) were analyzed for 1-butene and *cis*trans-2-butene. Palladium on barium sulfate catalyst, in the presence of hydrogen, was found to catalyze the rearrangement of 1-butene and 2-butene to an equilibrium mixture. Apparatus used in the work is described, as well as the purification of butadiene, preparation of the catalysts, hydrogenation procedure and the isolation of the products.

Catalytic Cracking of Pure Hydrocarbons. G. M. Good, H. H. Voge and B. S. Greensfelder, *Ind. and Eng. Chem.* **39** (1947) pp. 1032-6.

In previous papers in a series by the authors catalytic cracking of 56 pure hydrocarbons was reported. However, no detailed study was made of the effect of isomerism upon the extent of cracking and product composition. The present work was undertaken to show the effect of structural isomerism on the cracking behavior of certain hydrocarbons and particularly the five isomeric hexanes, cyclohexane and methylcyclopentane, *n*-octane, 2,2,4-trimethylpentane, *n*-propylbenzene, isopropylbenzene, three isomeric butylbenzenes, *n*-dodecane, isododecane, and Decalin and a naphthene and paraffin of 10 carbon atoms each. The cracking was effected over a silica-zirconia-alumina catalyst. Large differences in rate of cracking and product composition were observed and it was found that these could be correlated with the carbon atom groupings of the isomers. In particular, tertiary carbon atoms enhance the cracking rate markedly, and quarternary carbon atoms act in the opposite manner. Comparison of a paraffin and naphthene of selected C_{10} structure provides added information on cracking behavior. Data of the work are reported in considerable detail in six tables.

Manufacture: Processes and Plant

Mechanism of Countercurrent Gas Liquid Flow Through Packed Towers. Frederick A. Zenz, *Chem. Eng. Progress* **43** (1947) pp. 415-28.

The purpose of the paper is to present a method of predicting pressure drop, show the relationship between flooding and pressure drop, and in general give a clearer physical interpretation of packed tower operation. By analogy to flow through valves and orifices, a theory is presented which clarifies the characteristics of countercurrent flow through packed towers. This permits a definition of the "flooding point" that gives data that correlate as well or better than "visual" determinations, and permits a correlation of pressure drops at this "flooding point." From this same analogy an equation is derived that can be used to calculate the pressure drop at various flow rates. Experimental work that still must be done in the range of flows in which the liquid is the continuous phase, is indicated. A bibliography of 8 references is included.

Hydrocarbon Synthesis in the Presence of Cobalt Catalysts at Medium Pressures. C. C. Hall and S. L. Smith, *Jour. Inst. of Petroleum* **33** (1947) pp. 439-59.

The synthesis of hydrocarbons from carbon monoxide and hydrogen at a gauge pressure of 150 lbs. per sq. in. was studied using cobalt-thoria-magnesia-kieselguhr catalysts. At the time the work described in this paper was done, the only reliable information concerning the effect of a moderate increase in pressure in the Fischer-Tropsch synthesis was contained in two papers by Fischer and Pichler, these workers using cobalt catalysts of inferior performance at atmospheric pressure. Apart, therefore, from the general desirability of obtaining first-hand knowledge of the characteristics of the synthesis at pressures of the order of 10 atm., it was of particular interest to study the performance of the active cobalt - thoria - magnesia catalysts under these conditions. The paper contains an account of the more important laboratory-scale experiments carried out on these lines at the Fuel Research Station during the war years. The most efficient conversion to liquid and solid hydrocarbons was obtained using gas of H_2:CO ratio of 1.5:1. The results of the work are presented in considerable detail in 11 tables and 4 figures.

Fluidizing Processes. Basic Observations from Laboratory Equipment. Joseph D. Parent, Nathan Yagol and Charles S. Steiner, *Chem. Eng. Progress* **43** (1947) pp. 429-36.

A stream of gas can be forced upward through a bed or column of suitably sized solid material at a rate such as to cause the individual particles to be set in continuous motion of a rather complex pattern. After an initial abrupt expansion, which corresponds to the beginning of fluidization, the bed of solids expands continuously as the flow rate is increased. If the gas velocity is relatively low the appearance of the column of solids is like that of a boiling liquid, and the condition is called "dense phase" fluidization. When the gas velocity is high enough to carry over solids so that the boundary layer disappears fluidization is in full operation. This is the type of procedure that is obtained in a pneumatic conveyor. The authors studied the pressure drop attending the upward passage of gases through beds of fluidized solids. It was found equivalent to the suspension head opposing the flow regardless of the nature of the gas or solids or of the flow rate, provided smooth fluidization obtained. Three types of behavior have been noted for a bed of solids aerated in an upward direction: mechanically smooth fluidization, channeling, and slugging. For a given substance the particular behavior depends on the size distribution of the particles.

Recent Advances in the Use of High Pressures. E. W. Comings, *Ind. and Eng. Chem.* **39** (1947) pp. 948-52.

The industrial aplications of high pressures are becoming more numerous and involve larger scale apparatus. The literature of the last five years is reviewed and characteristic applications of high pressures are described. The use of high pressures is most common in the chemical industry, the petroleum industry and in the conversion of coal into liquid fuels. In this country the demand for aviation gasoline and chemicals from petroleum as well as the new techniques for handling natural gas involve the use of higher pressures. Studies concerned with reaction kinetics, catalyst mechanism, and the thermodynamics of reactions have a direct bearing on the use of high pressures. The importance of heat transfer, mass transfer, catalyst size, and gas flow conditions on the design of catalytic reactors is indicated. Much work has been done on the physical and thermal properties of pure compounds and their mixtures and on the phase equilibria of binary and multicomponent mixtures. Design of high pressure equipment is briefly discussed. A bibliography of 164 references bearing on this general subject is included.

Chemical Refining of Aromatic Hydrocarbons from Petroleum. P. L. Brandt, R. J. Lee and F. T. Wadsworth, *Ind. and Eng. Chem.* **39** (1947) pp. 1010-8.

The problems connected with the chemical refining of toluene from petroleum sources were studied. It was shown that the obtaining of a product of satisfactory acid-wash color and acid-wash color stability is intimately connected with the presence of certain reactive olefins. Diolefins are particularly harmful in the acid-wash color test even at such low concentrations as 0.005-0.01 percent. Most mono-olefins have little effect on acid-wash color. Reactions with maleic anhydride confirmed these conclusions. It is shown possible to refine toluene recovered from hydroformed naphthas with maleic anhydride. Vapor-phase treating with U.O.P. phosphoric acid catalyst is an effective method of toluene treating. Data are presented on the variables in conventional sulfuric acid treating, and on accelerated test methods to compare the efficiency of different treating conditions and to predict the acid-wash color stability of the product. A bibliography of 21 references is included, and the data secured in the course of the work are presented in considerable detail in 11 tables and 5 figures.

Aromatics from Petroleum. H. Steiner, *Jour. Inst. of Petroleum* **33** (1947) pp. 410-38.

Principles governing the formation of aromatics based on thermodynamics are reviewed. The formation of aromatics by dehydrogenation, cyclization, and isomerization is discussed. The hydroforming process makes use of all these reactions to produce toluene, xylenes, and in general, high octane gasolines. An alternative way of making aromatics from petroleum is by cracking at high temperatures. The chemical reactions occurring in these high temperature processes are outlined, and a process recently developed in Great Britain to produce aromatics together with low molecular weight olefins, such as ethylene and propylene, is described. A bibliography of 22 references is included.

Continuous Process for Lubricating Greases. H. G. Houlton, A. E. Calkins and A. Beerbower, *Chem. Eng. Progress* **43** (1947) pp. 399-404.

In general, lime, soda and similar greases that require the manufacture of soap as part of the grease-making procedure, were made batchwise in mechanically agitated, jacketed kettles. The authors describe a continuous process particularly with reference to lime-base greases. However, the procedure can be

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equally well adapted to soda-base and other greases in those processes in which it has been advantageous to manufacture soap as part of the grease-making procedure. The process described has been in commercial operation for about four years in the manufacture of lime grease at a rate of 60 lbs. per min. or 86,000 lbs. per day. Concentrated soap stock is first prepared, which, continuously blended with the lubricating oil, produces a grease uniform in character and of high quality. The savings in material, labor, and floor-space over the batch method are sufficient to amortize the plant costs in about one year's time. A flow sheet of the process is given as well as an isomeric view of plant layout.

Economic Process Operation. W. D. HARBERT, *Ind. and Eng. Chem.* **39** (1947) pp. 940-4.

One of the most important and difficult problems for a process engineer is the determination of the optimum operating conditions for a plant. In the present article a mathematical method is presented for the positive determination of the process conditions that give maximum profit. Complete interrelations of the process variables and costs of additional units of each of the variables are necessary for the calculation. Two illustrative examples are given, and the special requirements of the method are discussed. One example concerns the operation of a natural gasoline absorber. It gives the optimum recovery and oil circulation rates and shows how these figures change with the price of butane. A second example concerns the operation of a high temperature gas reactor and shows the optimum recycle ratio and optimum inlet gas temperature.

Evaluating Performance of Cooling Towers. JAMES G. DE FLON, *Chem. Eng.* **54**:7 (1947) pp. 112-6.

As stated by the author, the article is intended for the cooling tower user, rather than the designer, and presents a simplified method of examining cooling tower performance which, although it omits certain refinements, will still enable a thorough analysis of the characteristics of individual mechanical and natural draft towers to be made under a variety of conditions of use. Atmospheric and mechanical draft towers are capable of cooling water to the same minimum temperature. The economic situation, prevailing atmospheric condition and desired approach to the wet bulb temperature and the materials available will indicate which type to select. Both types of towers are discussed at some length.

Spiral Heat Exchanger. Heat-Transfer Characteristics. K. W. COONS, ALICE MEDORA HARGIS, PAUL Q. HEWES, FRANK T. WEEMS, *Chem. Eng. Progress* **43** (1947) pp. 405-414.

The spiral heat exchanger comprises a pair of plates wound one within the other in a spiral manner and so connected to headers that two separate channels of flow are formed. Work reported in the paper was done to make data on these exchangers available to practicing engineers. Heat-transfer characteristics of these exchangers are presented under varying conditions when heating or cooling oil, water, brine, and steam. The standard heat-transfer equations are considered in the light of the experi-

mental results obtained. When heating or cooling oils in the spirals under viscous-flow conditions the over-all coefficients are found to be 50 to 100 percent higher than the values calculated using conventional equations. Flow characteristics of the spirals are given. Turbulence begins at values of Re between 1400 and 1800. Pressure drop through the spiral channels at any given Reynolds number is lower than in smooth tubing. Using a spiral with 30 sq. ft. of surface, steam to water, an over-all coefficient of about 700 is obtained at a water velocity of 6.5 ft. In the same unit, exchanging water to water, a coefficient of 325 is obtained at water velocity of 5 ft. A bibliography of six references is included.

Progress in Petroleum Research. ROBERT PRICE RUSSELL, *Jour. of Inst. of Petroleum* **33** (1947) pp. 391-409.

The article is a review and discussion of trends, development and research in the field of petroleum. A chart presents the principal sources of world energy and another the trends in gasoline quality and engine compression ratios. The yields of products from a barrel of crude oil are shown at 10-year intervals starting with 1920 and estimated for 1950 and 1960. The author notes that the wide range of chemical and synthetic products now being made from petroleum utilizes only a fraction of 1 percent of the total world production. The principal function of petroleum is that of liquid fuel, and the author predicts that for many years to come petroleum will serve chiefly as a source of energy. The fluid catalytic cracking process is reviewed and compared to thermal cracking. When the plants now under construction are completed 58.5 percent of all plants will be fluid catalyst plants and their capacity will be 60 million tons per year. Typical yields and product qualities are tabulated for thermal cracking and for fluid catalytic cracking. Motor gasolines can be made today with existing catalytic cracking equipment and by other fully developed processes to operate in cars with engines of 9.5 to 10 compression ratio as against the present average compression ratio of slightly over 6. The second process discussed is hydrocarbon synthesis. In this the fluid catalyst technique is directed into conversion of natural gas and coal into liquid fuels. At present, synthesis from natural gas is closer to plant-scale appplication than synthesis from coal. The present cost of gasoline made synthetically from natural gas is approximately two-thirds the cost of gasoline made from typical crude oil. Gasoline made from coal costs slightly more than gasoline made from crude oil. The improvement of lubricants through additives is briefly discussed. Other subjects covered are chemical derivatives of petroleum, petroleum products in agriculture, synthetic resins and detergents and synthetic rubber.

Estimation of Instrument Costs. DOUGLAS M. CONSIDINE, *Chem. Eng.* **54:7 (1947)** pp. 108-9 and 122.

The estimation of the cost of instruments for a given process can often be approximated for preliminary purposes as a percentage of total installed cost of the process equipment, although this percentage may vary both with the process and with individual requirements. For greater accuracy detailed instrument costs are needed. The author lists the

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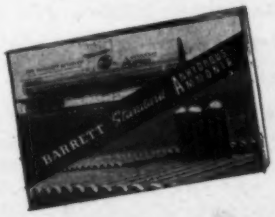

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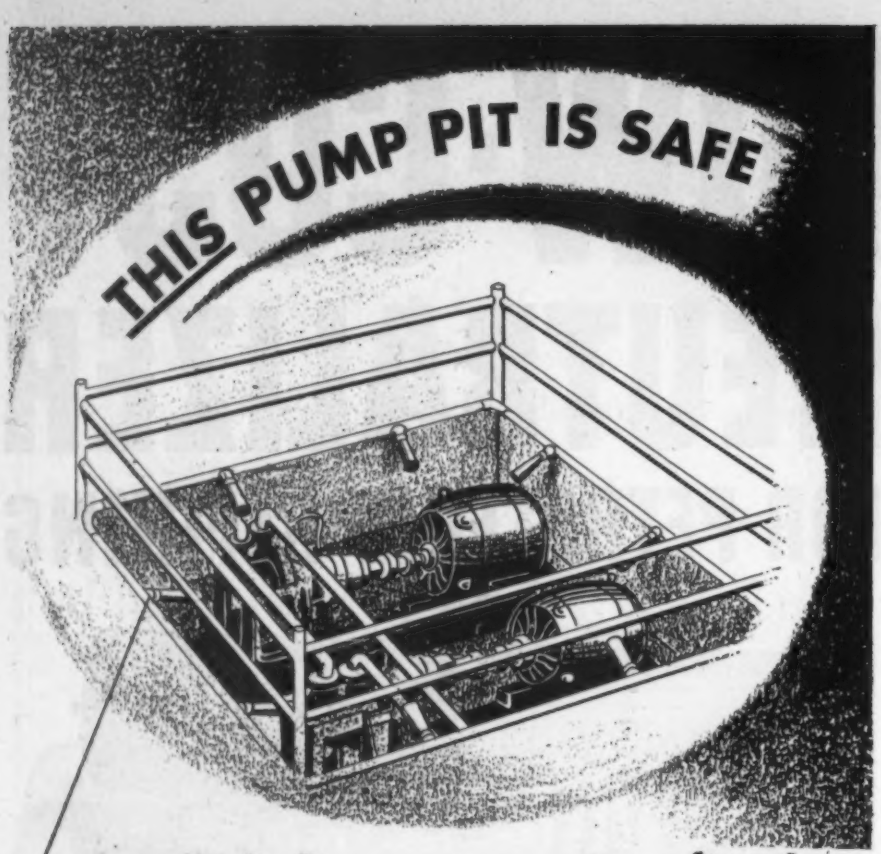

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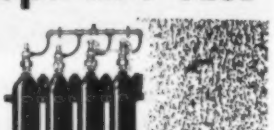

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base costs of typical instruments, and gives percentages to be added for accessories and for installation. A further tabulation of installed costs of instruments and the percentages of total process equipment costs are given for varied types of process plants.

Products: Properties, Utilization and Analysis

Analyses of Alkylates and Hydrocodimers. A. R. GLASGOW, JR., A. J. STREIFF, C. B. WILLINGHAM AND F. D. ROSSINI, *J. Research Natl. Bur. Standards* **38** (1947) pp. 537-81.

In the course of the work under Research Project No. 6 of the API the hydrocarbon components of 28 alkylates and hydrocodimers were determined, including sulfuric acid alkylates, hydrofluoric acid alkylates, sulfuric acid hydrocodimers and phosphoric acid hydrocodimers. Analyses were made by close fractionation at high reflux ratio, combined with values of refractive index. The heptanes were found to predominate in propylene alkylates, and nonanes in the pentene alkylates. The octanes are largest in butene alkylates and the dimer and trimer alkylates. The hydrocarbon isomers are formed in amounts that do not in general correspond to thermodynamic equilibrium. The heptanes present in large relative amounts are 2,4- and 2,3-dimethylpentane. The octanes present in large amounts are 2,2,4-, 2,3,4- and 2,3,3-trimethylpentanes. In the hydrocodimers, 2,3,4-trimethylpentane is the prevailing octane. One of the alkylates was spectrographically analyzed by six laboratories, and good agreement was found among the laboratories and between the results of different types of spectrometers. The results also agreed well with those of the analytical distillation work.

Determination of Tetraethyllead in Aviation Gasoline. Rapid Idometric Method. LESTER NEWMAN, JOHN F. PHILIP AND ADOLPH R. JENSEN, *Anal. Chem.* 19 (1947) pp. 451-3.

An iodometric method for the determination of tetraethyllead in aviation gasoline is given. The fuel is shaken with an excess of alcoholic potassium triiodide solution which reacts with the tetraethyllead. Interferences caused by olefins and aromatic amines are minimized, if necessary, by previous extraction with 70 percent (by volume) sulfuric acid. The excess iodine is titrated with sodium thiosulfate. The procedure requires about 15 minutes for two simultaneous determinations on the same fuel. The method is applicable to all aviation gasolines in current use. A maximum deviation of ±0.05 ml. of tetraethyllead per gallon is to be found when the results are compared to A.S.T.M. results.

Ashland Only Bidder

Ashland Oil & Refining Company was the only bidder on the surplus aviation gasoline plant located at Catlettsburg, Ky., which it now operates under lease extending through next January. Ashland's bid was for $2,153,125 of which about a third was to be cash. The price would increase if throughput over a five-year period exceeded 7500 barrels daily.

Digest of Recently Issued United States

Patents Pertaining to Petroleum Refining

Compiled by HEINZ HEINEMANN

REFINING

U.S.P. 2,423,774. Oil Determination. J. J. Heigl to Standard Oil Development Co.

The amount of mineral oil of known character in a foreign material, such as drilling mud, cores, and cuttings obtained during the drilling of an oil well, is determined by extracting the material with a solvent for the oil and comparing the amount of invisible light having a wave length of about 3650 Angstroms absorbed by the extract with the amount of light of the same wave length absorbed by the solvent alone.

U.S.P. 2,423,795. Recovery of Hydrocarbons and Acetone from Admixtures by Phase Separation and Azeotropic Distillation. J. A. Patterson to Standard Oil Development Co.

Aliphatic hydrocarbons and acetone are recovered from a distillate product of an extractive distillation system where acetone is employed as the solvent in the treatment of a complex hydrocarbon mixture. Water is added to the distillate product to effect a diphase separation of a hydrocarbon phase and an aqueous acetone phase. The hydrocarbon phase is distilled with sufficient water to form a ternary azeotropic composition with the hydrocarbons and all of the acetone still present. The hydrocarbons and acetone are recovered from the products thus formed.

U.S.P. 2,424,186. Sulfuric Acid Extraction of Isobutylene from Hydrocarbon Mixtures. J. W. Packie and W. H. Rupp to Standard Oil Development Co.

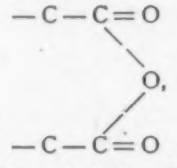
A hydrocarbon mixture containing paraffins, sec. and tert. eolfins is contacted in a first stage at a temperature of 90-110°F. with H_2SO_4 containing dissolved isobutylene (e.g. 0.2-0.6 mol of isobutylene per mol of 100% H_2SO_4). The major portion of isobutylene contained in the hydrocarbon mixture is thereby selectively dissolved. The solution formed is separated from the undissolved hydrocarbon mixture. The latter is contacted in a second stage at a temperature of 55-75°F. with fresh H_2SO_4 of 60-75% strength. The remaining portion of isobutylene is selectively dissolved and separated from the hydrocarbon mixture. The solution of isobutylene in H_2SO_4 from the second stage is recycled to the first stage as the dissolving medium. Isobutylene is thus obtained free of n-butylenes and is useful particularly in polymerization processes.

U.S.P. 2,424,841. Separation of Alkyl and Alkylene Naphthalene Isomers. J. E. Nickels to Koppers Co., Inc.

Alpha and beta ethylnaphthalene are separated from crude mixtures as obtained by the catalytic alkylation of naphthalene by catalytically dehydrogenating the mixture to form a mixture comprising alpha and beta vinylnaphthalene. The dehydrogenated mixture obtained is cooled to a temperature below 0°C. Pure beta vinylnaphthalene is crystallized out of the cooled mixture. If it is not desired to utilize the thus obtained beta and alpha vinylnaphthalenes as such but the corresponding ethylnaphthalenes, the beta vinylnaphthalene is hydrogenated to form substantially pure beta ethylnaphthalene, and the mother liquor from the crystallization step which contains alpha vinylnaphthalene is also hydrogenated to produce alpha ethylnaphthalene.

U.S.P. 2,424,948. Process for Removing Cyclopentadiene from Fore-runnings. J. H. Wells and P. J. Wilson to Cargenie-Illinois-Steel Corp.

A forerunning fraction from the light oil produced in the by-product coking of coal and having an endpoint distilling temperature of not more than 60°C. is freed from cyclopentadiene by directly reacting the latter with an alpha, beta-unsaturated carbonyl compound containing the group



such as maleic anhydride. The reaction temperature shall not be higher than 15°C. to prevent polymerization of the cyclopentadiene. The reaction product can be separated from the light oil fraction by filtration. The crystalline reaction product obtained can be used in the production of varnishes and other coating compositions.

U.S.P. 2,424,987. Process for the Concentration of Acetylene. R. M. Isham to Danciger Oil and Refineries, Inc.

Acetylene is concentrated from gaseous mixtures by contacting the mixtures with tetrahydrofurfuryl acetate. This material has a high solvent power for acetylene. The acetylene containing gas mixture is preferably contacted with the solvent while in a compressed state. Upon evolution of the dissolved gases by reduction of pressure and heating a gaseous mixture greatly enriched in C_2H_2 is obtained.

U.S.P. 2,425,175. Process for Breaking Petroleum Emulsions. P. G. Carpenter to Hercules Powder Co.

Petroleum emulsions of the water-in-oil type are treated with an aminated chlorinated paraffin, or a salt thereof, characterized by a nitrogen content of about 1-11% and a chlorine content of about 2-20%. The emulsion breaking composition can be prepared by chlorinating a paraffin wax or other suitable hydrocarbons to a chlorine content of 15-50% and then aminating this chloro compound with ammonia to replace part of the chlorine by amino groups.

U.S.P. 2,425,535. Separation of Normal Paraffins from Iso-Paraffins by means of Activated Cocoanut Charcoal. H. J. Hibshman to Standard Oil Development Co.

Normal paraffins, such a n-heptane, are separated from a mixture with branched chain paraffins, such as isooctanes particularly from mixtures of paraffins with 6-10 C atoms and free from other types of hydrocarbons, by passing the mixture into contact with a sufficient quantity of activated cocoanut charcoal to preferentially absorb the normal paraffins from the mixture. Unabsorbed paraffins, i. e. mainly branched chain paraffins are withdrawn from the charcoal residual. The normal paraffins can be desorbed from the charcoal by washing it with a lower boiling branched chain paraffin solvent. Isopentane can, for example, be employed as the eluting agent for normal heptane.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,423,813. Apparatus for Handling Contact Masses. C. H. Lechthaler and R. Lee to Socony-Vacuum Oil Co., Inc.

The system according to this patent serves for the conversion of hydrocarbons in the presence of a particle form solid contact mass. The system comprises a reaction zone with means to introduce and to remove the solid contact mass, and means to introduce hydrocarbon reactants and to remove the reaction products. A regeneration zone for the contact mass is provided, and a fluid regeneration medium can be passed through this zone. Spent contact mass is transferred from the reaction zone to the regenerator and back to the reaction zone after regeneration. A portion of the moving stream of contact mass is diverted at a point between the regenerator and the reactor. This diverted mass is scrubbed while passing downwardly as a shower through a vertical passage while a gas is flowing upwardly through this passage at a controlled velocity sufficient to remove finer particles of contact mass from the shower. The gas laden with fines is removed separately from the passage while the removed cleaned contact mass is

returned to the cycle. The fines are discharged from the system.

U.S.P. 2,423,833. Fluid Catalytic Conversion of Hydrocarbon Oils. J. H. Hirsch to Foster Wheeler Corp.

Acid treated clay or bentonite, particularly Super-Filtrol, heated in a catalyst regenerating zone is passed to a reaction zone while a compound of Cr convertible to Cr_2O_3, such as a solution of chromium nitrate, is injected into this flowing stream before it reaches the reaction zone. The Cr compound is converted to Cr_2O_3 by contact with the heated clay and this oxide is simultaneously deposited on the clay. The catalyst thus produced is employed in the reaction zone for the fluid conversion of hydrocarbon oil. The spent catalyst is recycled to the regeneration zone. Naphtha hydroforming can be carried out in this process in the absence of external hydrogen and at relatively low pressure.

U.S.P. 8,423,947. Catalytic Reforming Process. E. C. Pfitzer to Standard Oil Co. of Indiana.

High knock rating motor fuels are produced from low knock rating gasoline or naptha by contacting the vapors of the charge material at conversion temperatures with a solid, porous, refractory catalyst consisting of Al_2O_3 gel promoted by a minor amount of an oxide of Cr, Mo, W, V, or U. The Al_2O_3 gel is prepared by coagulating a solution of an alkali metal aluminate with controlled addition of acid in stoichiometrical proportions. The gelatinized aluminate obtained is washed free of alkali metal salts, dried and ignited. The promoter can be added before drying the gel.

U.S.P. 2,423,951. Catalytic Process for the Production of Butadiene and Catalyst Therefor. L. R. U. Spence and D. J. Butterbaugh to Rohm & Haas Co.

Ethanol vapors are passed over a catalyst comprising ZnO modified with a zinc silicate, phosphate, or tungstate at a catalyst temperature of 375-500°C. The gaseous mixture obtained contains butadiene which is separated.

U.S.P. 2,424,083. Supported Silver Catalyst. H. de V. Finch and I. Bergsteinsson to Shell Development Co.

The new catalyst, useful particularly in the direct catalytic oxidation of olefins to olefin oxides, consists of a granular porous support material and an adherent, uniform, pellicular deposit of Ag metal formed upon and in the presence of the support material by the action of a reducing agent upon an ammoniacal solution of a silver salt, such as $AgNO_3$, and an alkali metal hydroxide.

U.S.P. 2,424,084. Process for the Manufacture of Olefin Oxides. H. de V. Finch and I. Bergsteinsson to Shell Development Co.

Olefin oxides, such as ethylene oxide, are produced by reacting the corresponding olefins, such as ethylene, with oxygen in excess of the stoichiometrical amount necessary to combine with the olefin at a temperature of 100-500°C. in the presence of a silver catalyst of the kind described in U. S. patent 2,424,083.

U.S.P. 2,424,085. Supported Silver Catalyst and its Preparation. I. Bergsteinsson and H. de V. Finch to Shell Development Co.

The new catalyst consists of particles of silicon, silicon carbide, or their mixtures and an adherent pellicular deposit of Ag metal formed thereon in the manner described in U. S. patent 2,424,083.

U.S.P. 2,424,086. Production of Olefin Oxides. I. Bergsteinsson and H. de V. Finch to Shell Development Co.

The process of this patent corresponds to that of U. S. patent 2,424,084, making use, however, of the catalyst described in U. S. patent 2,424,085.

U.S.P. 2,424,152. Titania Gel-Boria Catalyst and its Method of Preparation. G. C. Connolly to Standard Oil Development Co.

The new catalyst, which is particularly suitable for the catalytic treatment of hydrocarbon oils, consists essentially of a titanic gel having an apparent density of about 0.8-1.3 grams per cu. cm. when in 4-12 mesh granules and impregnated with boria. The weight % of boria with respect to the titania in the catalyst is from 5-20%. The new catalyst is very stable at high temperatures.

U.S.P. 2,424,467. Catalytic Conversion and Catalytic Drying. E. A. Johnson to Standard Oil Co. of Indiana.

An aqueous catalyst sol which on standing would set into a solid gel and which contains at least 30 mols of water per mol of catalyst solid (e. g. a silica alumina gel), is dispersed before it reaches the solid state into a heated fluid stream of combustion products or other hot gas. The particles of the hydrous catalyst suspended in this stream are gelled in the suspended state. The gelled catalyst is then dehydrated out of contact with restricting surfaces and under conditions to avoid connate internal stresses to produce uniform heat-stable, catalytically active particles. The catalyst thus obtained can be used for the conversion of hydrocarbons by contacting the latter at reaction temperature with a dense moving confined stream of the catalyst.

U.S.P. 2,425,074. Hydrocarbon Conversion with Friedel-Crafts Type Catalyst. R. C. Waugh to Standard Oil Co. (Indiana.)

In an active metal halide hydrocarbon isomerization system the hydrocarbon content of the catalyst complex is maintained within the approximate range of 23-40% by weight by adding thereto a solution of active metal halide in a light normally liquid paraffinic hydrocarbon. This solution is formed at elevated temperature and pressure in the absence of deleterious complex-forming materials and under substantial hydrogen pressure. A larger amount of active metal halide can be dissolved in this way than could be incorporated in the solution at lower temperature. The process can also be applied to other conversion processes than the isomerization of hydrocarbons.

U.S.P. 2,425,087. Conversion of Hydrocarbons in the Presence of a Catalyst Consisting Essentially of Titania Gel and Boron Oxide. J. D. Danforth to Universal Oil Products Co.

Hydrocarbon oils are contacted under conversion conditions with a catalyst which essentially consists of titania gel and boric oxide. This catalyst is preferably employed in the cracking of hydrocarbon oils, e. g. at 800-1100°F. The catalyst can, for example, contain 5-30% by weight of B_2O_3 with respect to the titania gel.

CRACKING AND REFORMING

U.S.P. 2,423,493. Hydrocarbon Conversion. H. O. Folkins to The Pure Oil Co.

Hydrocarbons are subjected to suitable cracking conditions of time, temperature, and pressure, e. g. heated to 375-750°C., in the presence simultaneously of a small amount of O and a small amount of Br or I. The minimum amounts of O and halogen in the mixture undergoing conversion shall be about .05 and .005 mole %, respectively, and the maximum combined amount of O and halogen in the mixture shall be about 5 mole %. For example, hydrocarbons boiling above the gasoline boiling range, or such rich in propane or butane can be cracked by this process to form olefins. Thermal cracking of hydrocarbons is greatly accelerated by the sensitizer mixture.

U.S.P. 2,423,494. Cracking of Hydrocarbons in the Presence of Halogen-Containing Sensitizers. H. O. Folkins and C. M. Tracker to The Pure Oil Co.

This process is similar to that of U. S. patent 2,423,493, but the catalyst is here composed of a mixture of Br or I and a poly-chlorinated aliphatic hydrocarbon, such as 1, 2, 3-trichloropropane or chloroform.

U.S.P. 2,423,527. Process and Apparatus for the Cracking of Carbonaceous Material. M. Steinschlaeger.

A fuel, such as tar or oil gas, is at least partially burnt in a burner to produce combustion gases. These gases are mixed with oil under such conditions that the sensible heat of the combustion gases is sufficiently high to crack the oil. The mixture of cracking products and combustion gases is passed through two heat exchangers in series to cool it. The cooled mixture is passed through a cooler to remove tar, heavy hydrocarbons and steam. The uncondensed residue is passed through a compresser. The compressed mixture, preferably after separation of newly condensed constituents, is heated by passing through one of the heat exchangers and is then passed through a gas turbine. The exit gases from this turbine are heated by passing them through the other heat exchanger. The thus heated gases are passed while still under pressure through a second gas turbine. The process is a continuous one and can also be used for cracking hydrocarbon gases, such as natural gas or coke oven gas. Carbon monoxide, hydrogen and nitrogen and mixtures of the same can, for example, be produced in the required purity and concentration for use in the Fischer-Tropsch synthesis, ammonia synthesis, or hydrogenation or refining processes. The entire power and steam requirements for the process can be generated in the indicated manner.

U.S.P. 2,423,637. Process and Apparatus for the Catalytic Cracking of a Hydrocarbon Oil. E. F. Chandler.

Liquid hydrocarbon oil is vaporized by indirect heat exchange with hot cracked vapors issuing from a first and second thermal catalytic cracking zone. The vapors obtained are expanded and fractionated in a first fractionating zone. A lower boiling fraction is removed as a vapor from this zone while a higher

boiling fraction is condensed. The hot condensate is subjected to direct evaporation and selective cracking in the first catalytic cracking zone for optimum conversion. The cracked vapors are expanded and dephlegmated in a second fractionating zone while in admixture with the previously separated lower b.p. fraction. Motor fuel vapors are removed from the second fractionating zone and condensed. A heavier fraction is condensed in this second fractionating zone, then removed from this zone, vaporized and further separately selectively cracked in the second catalytic cracking zone. The cracked vapors obtained are commingled and expanded with those obtained from the first cracking zone. The mixed cracked hydrocarbons are fractionated in the second fractionating zone. The heavier condensate therefrom is recycled to the second cracking zone.

U.S.P. 2,423,674. Process of Catalytic Cracking of Petroleum Hydrocarbons. P. H. W. Agren to A. Johnson & Co.

A petroleum oil to be cracked is passed into a hole drilled in a natural oil-shale rock formation while heating the drilling hole to cracking temperatures (e. g. 250-600°C.). This is done until the natural oil content of the formation is exhausted. The resulting products are withdrawn from the hole. Thereafter oil is continued to be passed into the hole and cracked therein utilizing the catalytic properties of the natural rock formation to enhance the cracking of the petroleum oil.

U.S.P. 2,424,997. Production of Aviation Gasoline. R. H. Newton to Houdry Process Corp.

Cracked hydrocarbons having an end point not exceeding 500°F. are cut into at least two fractions and treated under differing conditions separately with high activity silicious cracking catalysts. The heavier cut is subjected to the more severe treatment. The temperatures of the treatments shall be between 750° and 950°F. Hydrocarbons in the aviation gasoline boiling range are segregated from the product obtained and combined.

U.S.P. 2,425,482. Pretreatment of Reactivated Hydrocarbon Cracking Catalyst with Normally Gaseous Olefins. C. E. Moser to The Texas Co.

Hydrocarbon oil boiling higher than gasoline is cracked by contact at elevated temperature with a silica alumina catalyst which is periodically reactivated by burning off carbonaceous impurities. The reactivated catalyst prior to its contact with the feed oil is treated with normally geaseous hydrocarbons consisting essentially of olefins at substantially the elevated cracking temperatures. The contact of the catalyst with the feed oil is then resumed in the absence of olefins used in the pretreatment. The octane rating of the gasoline obtained by the cracking operation is improved by pretreating the catalyst in the described manner.

U.S.P. 2,425,532. Process for Removing Inorganic Impurities from Mineral Oils Preparatory to Catalytic Cracking. C. H. Hemminger to Standard Oil Development Co.

Salt-containing crude is introduced into an upper intermediate point in a fractionating zone while hot cracked vapor products are separately introduced into the bottom portion of this zone. A

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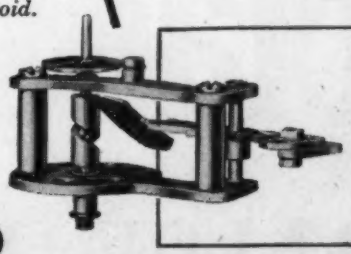

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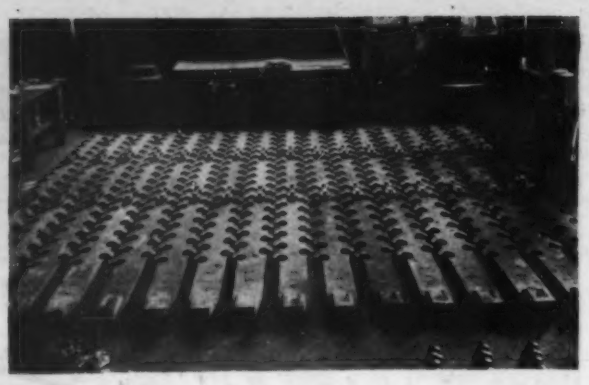

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fraction comprising unvaporized salt-containing crude and a light condensate obtained from the vapors at an upper point in this zone but below the point of introduction of the crude are separately collected. The fraction so collected is filtered to remove salt. An intermediate condensate fraction is separately collected at a lower point in the fractionating zone and removed. An initial heavy condensate fraction is separately collected in the bottom portion of the fractionating zone and is separately withdrawn. The intermediate fraction is combined with the filtered fraction. The resulting mixture is cracked in the presence of an active catalyst at cracking temperature for a period sufficient to convert a substantial portion of this mixture into gasoline. The resulting hot cracked vapor products are introduced into the fractionating zone as indicated before.

ISOMERIZATION

U.S.P. 2,423,612. Isomerization of Olefins. M. J. Mulligan and P. L. Cramer to General Motors Corp.

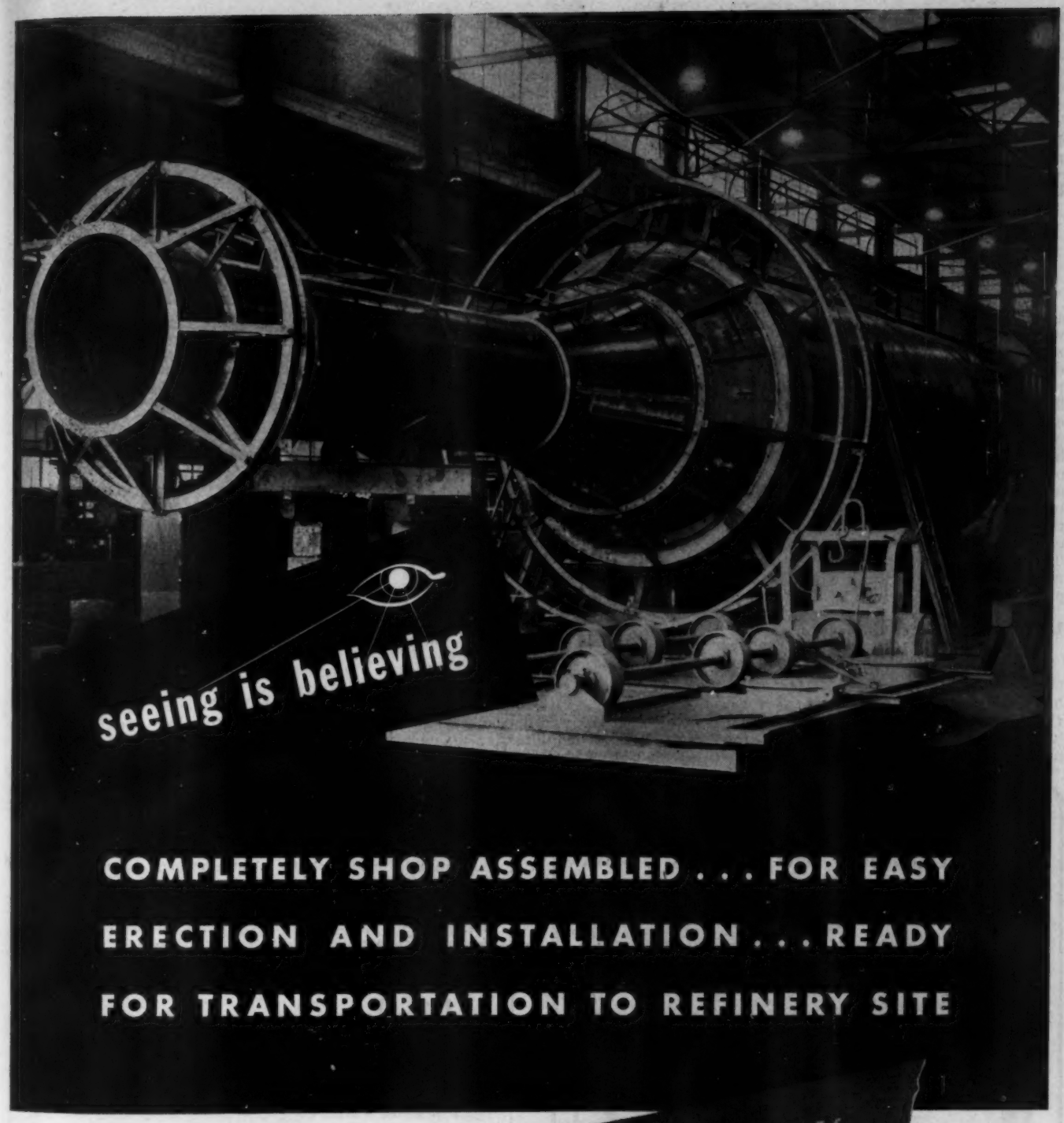
An olefin, such as 2, 3-dimethyl-1-butene, or 2-pentene, or 1-hexene, is treated under isomerizing conditions, e. g. at a temperature of 420-630° F. with aluminum sulfate supported on diatomaceous silica of slightly acid reaction. An isomeric olefin is obtained. The life and efficiency of the catalyst, such as anhydrous or dehydrated aluminum sulfate, is greatly increased by its deposit on the said carrier.

U.S.P. 2,423,845. Method of Increasing the Usefulness of Solid Isomerization Catalyst Masses. N. F. Myers to Standard Oil Development Co.

Normal paraffin with at least 4 C atoms, such as n-butane, is isomerized in the vapor phase by contacting it under suitable conditions and in the presence of a small amount of HCl as promoter with a catalyst mass comprising a carrier dehydrated to a water content of less than 2%, such as dehydrated bauxite, and containing sorbed $AlCl_3$. A gasiform carrier containing $AlCl_3$ vapors and substantially free of HCl is added at least intermittently during the isomerization process to the catalyst mass, thus maintaining the amount of $AlCl_3$ sorbed in the carrier between about 8 and 20% by weight of the catalyst mass. The carrier gas is preferably at least a portion of the feed stock to be isomerized.

U.S.P. 2,423,846. Vapor Phase Isomerization of Normal Paraffins. H. G. Corneil to Standard Oil Development Co.

The process of this patent is similar to that of U. S. patent 2,423,845. A body of a metal halide vaporizable at a temperature below 500° F., such as $AlCl_3$, is placed in front of a bed of porous material adapted to absorb the metal halide and maintained at a temperature of 275-500° F. so that it will absorb and retain the major portion of the metal halide contacted with it. A vaporized normal paraffinic hydrocarbon with more than 3 C atoms is passed in sequence through the body of metal halide and the bed of porous material for a length of time sufficient to transfer the desired quantity of the metal



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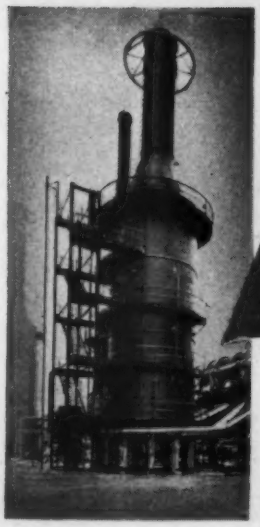

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halide to and deposit it on the porous material. Thereafter the passage of vaporized hydrocarbon through the bed of porous material alone is continued while a gaseous halide promoter is added to isomerize the hydrocarbon. The isomerized hydrocarbons formed are recovered from the products leaving the reaction system.

U.S.P. 2,424,953. Isomerization of Paraffins in the Presence of Nascent Aluminum Halide and a Heterocyclic Compound. C. G. Myers, R. C. Hansford, and A. N. Sachanen to Socony-Vacuum Oil Co., Inc.

A paraffinic hydrocarbon with 5-7 C atoms is contacted in a reaction zone with a nascent aluminum halide isomerization catalyst formed in this zone under the isomerization reaction conditions, in the presence of one of the following compounds: thiophene, furfuraldehyde, furan, pyridine, piperidine, alpha-picoline, carbazole, indole, or quinoline. The amount of the added compound shall be such as to permit the isomerization reaction and to materially suppress side reactions. When using thiophene as the additive it should be employed in an amount of preferably 0.5-2% and not more than 2-5% by weight of the hydrocarbon charged, e. g. pentane.

U.S.P. 2,425,268. Isomerization of Normal Paraffins. E. E. Sensel to The Texas Co.

A feed of normal paraffin hydrocarbons is continuously passed to a reaction zone which contains aluminum halide isomerization catalyst in the presence of hydrogen halide. The reaction zone is maintained at a temperature of 75-212°F. Small amounts of low boiling olefin and isoparaffin hydrocarbons are continuously added to the feed prior to its introduction to the reaction zone. The amount of added ole- 1% to 5% by volume on a liquid basis of the total feed and the amount of fin is within the range of a fraction of added isoparaffin is in a molar ratio of at least 0.8 with respect to the olefin and does not exceed 11% by volume of the normal paraffins to be converted. Isomerization of saturated feed hydrocarbons is effected to a substantial extent as the principal reaction during passage of the hydrocarbons through the reaction zone. Reaction products are continuously withdrawn from this zone. The proportions of added olefin and isoparaffins are sufficient so that the reaction products are substantially richer in isomerized feed hydrocarbons than when the reaction is effected under otherwise similar conditions in the absence of the added olefins and isoparaffins. A normally gaseous olefin and an isoparaffin of 4-5 C atoms can, for example, be employed as the additives in the isomerization of normal paraffins with 4-6 C atoms.

U.S.P. 2,425.340. Production of Hydrocarbons. A. C. Nixon and O. L. Davis to Shell Development Co.

Blending agents for gasoline are produced by isomerizing a polymer of an olefin with 3-5 C atoms. The isomer of increased power output thus obtained is treated to depolymerize unisomerized polymer present, and the isomerizate is then hydrogenated. Octanes of high supercharged rating can, for example, be obtained by contacting di-isobutylene with an isomerization catalyst, reacting the resulting mixture of di-isobutylene and octene isomerization products thereof in the presence of a calcined sulfamic acid and treated alumina catalyst to depolymerize the di-isobutylene, separating the depolymerization products and hydrogenating the remaining octenes.

U.S.P. 2,425,416. Preparation of Isoparaffins. D. C. Bond and M. Savoy to The Pure Oil Co.

Ethylene is contacted with anhydrous zirconium tetrachloride at a temperature of about 250-570°F. in the presence of HCl. The volume ratio of HCl to ethylene shall be between 0.15 and 0.5. Isoparaffins, particularly isobutane, are obtained beside ethyl chloride.

ALKYLATION

U.S.P. 2,423,470. Alkylation of an Acyclic Organic Compound with an Alkylation Agent Using Hydrogen Fluoride as Catalyst. J. H. Simons to E. I. du Pont de Nemours & Co.

An acyclic organic compound containing a replaceable hydrogen atom, is treated with an alkylating agent in the presence of HF as the sole effective alkylation catalyst. For example, benzene, phenol, toluene, naphthalene, cyclohexene, and the like can be alkylated with propylene, isobutylene, propyl or butyl chloride by means of HF. This

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Fig. 21 Fig. 22

Fig. 12

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Fig. 13

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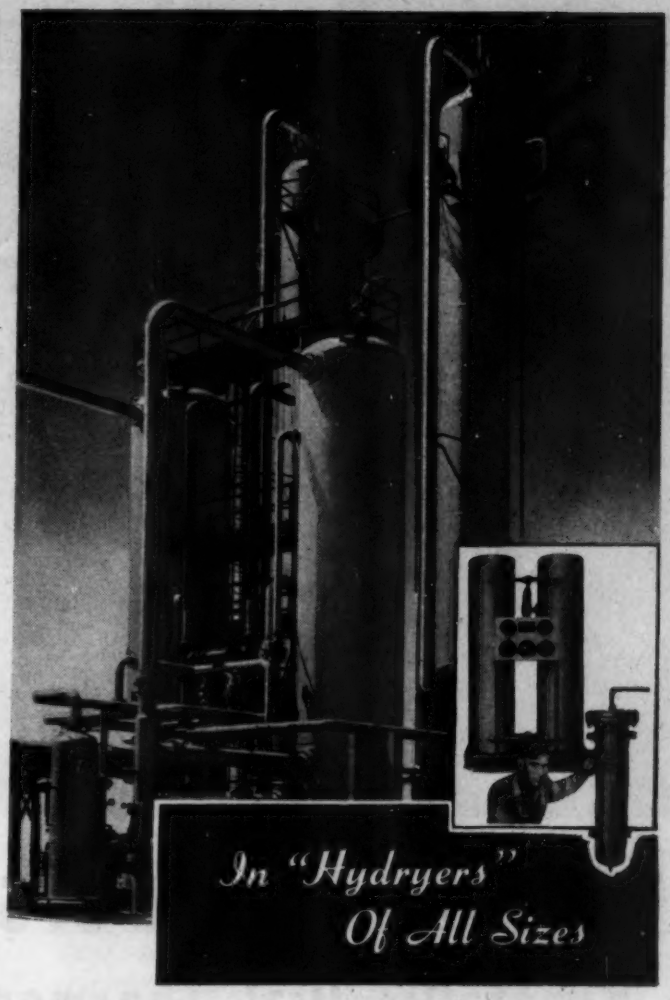

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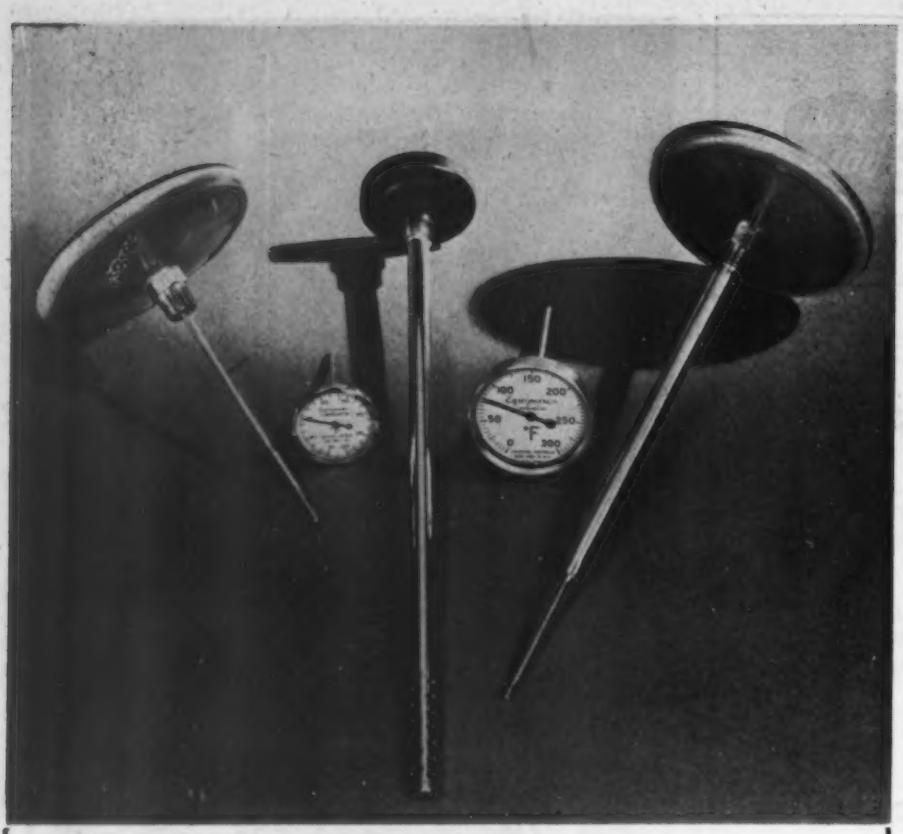

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catalyst makes possible the alkylation under such conditions that the formation of tars and resins is very small, polymerization is reduced to a minimum, and a high yield of very pure alkylation products is obtained.

U.S.P. 2,423,530. Alkylation of Aryl Hydrocarbons. C. M. Thacker and R. C. Swann to The Pure Oil Co.

Alkyl benzenes, such as ethyl benzene, are synthesized by reacting benzene with an aliphatic mercaptan or an alkyl sulfide at a temperature of 100-400°C. in the presence of a Friedel-Crafts catalyst, such as $FeCl_3$, for a period of time sufficient to permit formation of a substantial quantity of alkyl benzene, e. g. for not less than 30 minutes.

U.S.P. 2,425,462. Alkylation of Hydrocarbons. L. U. Franklin to Gulf Oil Corp.

A mixture of hydrocarbons comprising olefins and isoparaffins is passed through a catalyst bed made up of discrete particles of anhydrous $AlCl_3$ in the absence of any inert carrier. The content of olefins in the feed stock is maintained in the range of about 0.1-2.5%. The flow of hydrocarbons over the catalyst is maintained at such a rate that the time of contact with hydrocarbons with catalyst will be between 1-10 seconds. The temperature is maintained at about 50-75°F. Alkylation is effected at a very satisfactory rate and the catalyst bed is maintained firm and porous under these conditions.

POLYMERIZATION AND CONVERSION

U.S.P. 2,423,760. Method of Polymerizing Isobutylene. N. M. Elmore to Standard Oil Development Co.

A liquefied isoolefin, such as isobutylene, is mixed with a diluent-refrigerant, such as liquid ethylene, at a temperature below —101°C. Liquid, dissolved BF_3 is added while stirring until a homogeneous mixture is obtained without polymerization of the olefin. A reaction initiator comprising butyl alcohol is then applied to the mixture to initiate the polymerization reaction.

U.S.P. 2,423,835. Inert Heat Material in Contact Mass Catalysis. E. J. Houdry to Houdry Process Corp.

Hydrocarbon conversion processes, such as the dehydrogenation of gaseous hydrocarbons to produce unsaturates, are carried out in a reaction chamber containing a combination of catalytic material and inert heat absorbing material in the ratio of at least 1:3, and the on-stream periods are limited to less than 30 minutes. The operating conditions are adjusted to maintain the combined contact mass at a predetermined mean temperature in excess of 850°F. during on-stream periods in a continuing cycle of heat liberated and absorbed by the mass during the alternating regenerating periods. The reaction and regeneration reactants are fed to and through the reaction chamber in the same direction. The direction of feed is reversed after each regeneration.

U.S.P. 2,423,850. Process for Effecting Catalytic Conversions with Finely Divided Catalyst. N. E. Peery to Shell Development Co.

In a fluid catalyst system in which a continually renewed finely divided cata-

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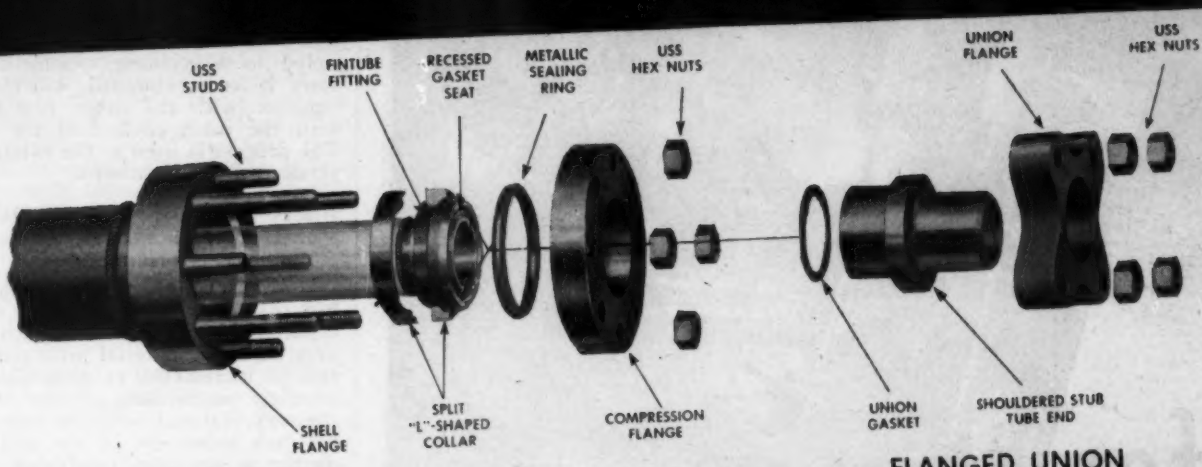

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lyst is contacted with a gas or vapor stream which tends to carry in suspension a portion of the catalyst from the system, a portion of the main catalyst mass is separated into at least 3 fractions of course, intermediate size and fine particles, respectively. The fraction of intermediate size particles is subjected to a grinding treatment whereupon it is recombined individually or together with the other two fractions with the main portion of the catalyst. The process is used in the catalytic conversion of hydrocarbons.

U.S.P. 2,423,907. Catalytic Conversion of Hydrocarbons. W. A. Schulze to Phillips Petroleum Co.

Hydrocarbons are passed through a bed of a catalyst of relatively low heat capacity admixed with a relatively high heat capacity material arranged in successive increments of progressively decreasing proportions of the high heat capacity material whereby heat retained by each increment of the catalyst bed during a previous exothermic catalyst reactivation period corresponds substantially to the quantity of heat potentially required by that increment in effecting endothermic conversion of the hydrocarbons. Reactivation gas containing free O is passed during the exothermic reactivation period through the catalyst bed to remove carbonaceous material by combustion whereby heat of combustion is retained by said increments in proportion to the amount of high heat capacity material present in each increment. Alfrax or a chrome-iron alloy shot can, for example, be used as the high heat capacity material, while a silica-alumina gel type catalyst can, for example, be employed in the cracking of gas-oil, or a chromia-alumina catalyst in the dehydrogenation of n-butane or the like.

U.S.P. 2,424,143. Polymerization of Olefins. O. A. Brown to Standard Oil Development Co.

An interpolymerization product of a secondary olefin, such as propylene, with a tertiary olefin, such as isobutylene, is produced by first selectively absorbing a tertiary olefin in H_2SO_4 of a temperature not higher than 125°F. to prevent substantial copolymerization of this olefin and by separately selectively absorbing a secondary olefin in H_2SO_4 under corresponding conditions. The second of the two extracts thus obtained is then heated to a temperature of at least 150°F., mixed with the first named extract while maintaining a substantial excess of secondary olefin over tertiary olefin and a temperature of at least 150°F. in the mixing zone. Rapid interpolymerization is effected.

U.S.P. 2,424,147. Controlling Catalyst-Oil Ratio by Use of a Venturi. D. L. Campbell to Standard Oil Development Co.

A method of converting hydrocarbons is described in which a desired powdered catalyst to oil ratio is maintained and the powdered catalyst is delivered to a mixing zone as a fluidized stream from a standpipe. A hydrocarbon vapor stream is mixed with the catalyst stream in the mixing zone and the mixed stream is then passed as a suspension through a combination of a restriction and a reaction zone in series. The reaction products are separated from catalyst in a separating zone. The rate of fluidized

catalyst delivery to the mixing zone is controlled by a valve in the standpipe and this valve is in turn controlled by the static pressure differential through the restriction.

U.S.P. 2,425,463. Catalytic Conversion of Hydrocarbons. A. D. Garrison to Texaco Development Corp.

Hydrocarbon oil, such as gas-oil vapor, is contacted at a temperature of about 800-950°F. with a catalyst comprising alumina which has first been subjected to dehydration of such extent that not more than about 7% of firmly bound water remains in the catalyst and has then been treated with anhydrous silicon tetrafluoride to effect absorption of the latter by the catalyst in amounts of about 5-15% by weight of the catalyst. Gasoline hydrocarbons are obtained by this conversion process.

U.S.P. 2,425,506. Production of Premium Aviation Fuel Components. S. R. Bethea to Standard Oil Development Co.

A C_4-fraction including a major amount of normal mono-olefin is catalytically dehydrogenated. The product obtained includes substantial amounts of mono-olefin, diolefin, and hydrocarbons boiling above 110°F. The resultant product is distilled to separate a fraction boiling between 110-350°F. This fraction is contacted with clay at a temperature of about 400°F. to polymerize at least a major portion of the diolefin therein. The product removed from the clay treating step is distilled to separate a fraction boiling up to 350°F. This fraction is then mildly hydrogenated to obtain a fraction suitable for inclusion in a premium aviation fuel.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,424,636. Catalytic Dehydrogenation of Hydrocarbons. J. O. Smith to Tide Water Associated Oil Co.

Aliphatic hydrocarbons are contacted under dehydrogenating conditions with a catalyst comprising molybdenum oxide on zirconium oxide on alumina, or zirconium oxide on molybdenum oxide on alumina. For example, the catalyst can comprise 6% molybdenum oxide and 10% zirconium oxide, and can advantageously be used for the dehydrogenation of naphthenes.

U.S.P. 2,424,637. Process and Catalyst for Aromatizing Aliphatic Hydrocarbons. J. O. Smith to Tide Water Associated Oil Co.

A catalyst of the type indicated in U. S. patent 2,424,636 and containing 1-10% by weight of zirconium oxide and 1-12% of molybdenum oxide on alumina which contains not more than about 1% silica is employed for aromatizing aliphatic hydrocarbons, particularly straight chain paraffins,, without excessive coke formation.

U.S.P. 2,423,681. Use of Magnesia Catalysts in the Production of Butadiene. D. J. Butterbaugh and Le Roy U. Spence to Roehm & Haas Co.

Ethanol is vaporized. The vapors are passed over a catalyst comprising MgO admixed and digested with silica in the presence of or dissolved in a strongly alkaline material. The catalyst is maintained at a temperature of 375-525°C. The butadiene formed is separated from the gaseous mixture.

DESULFURIZATION

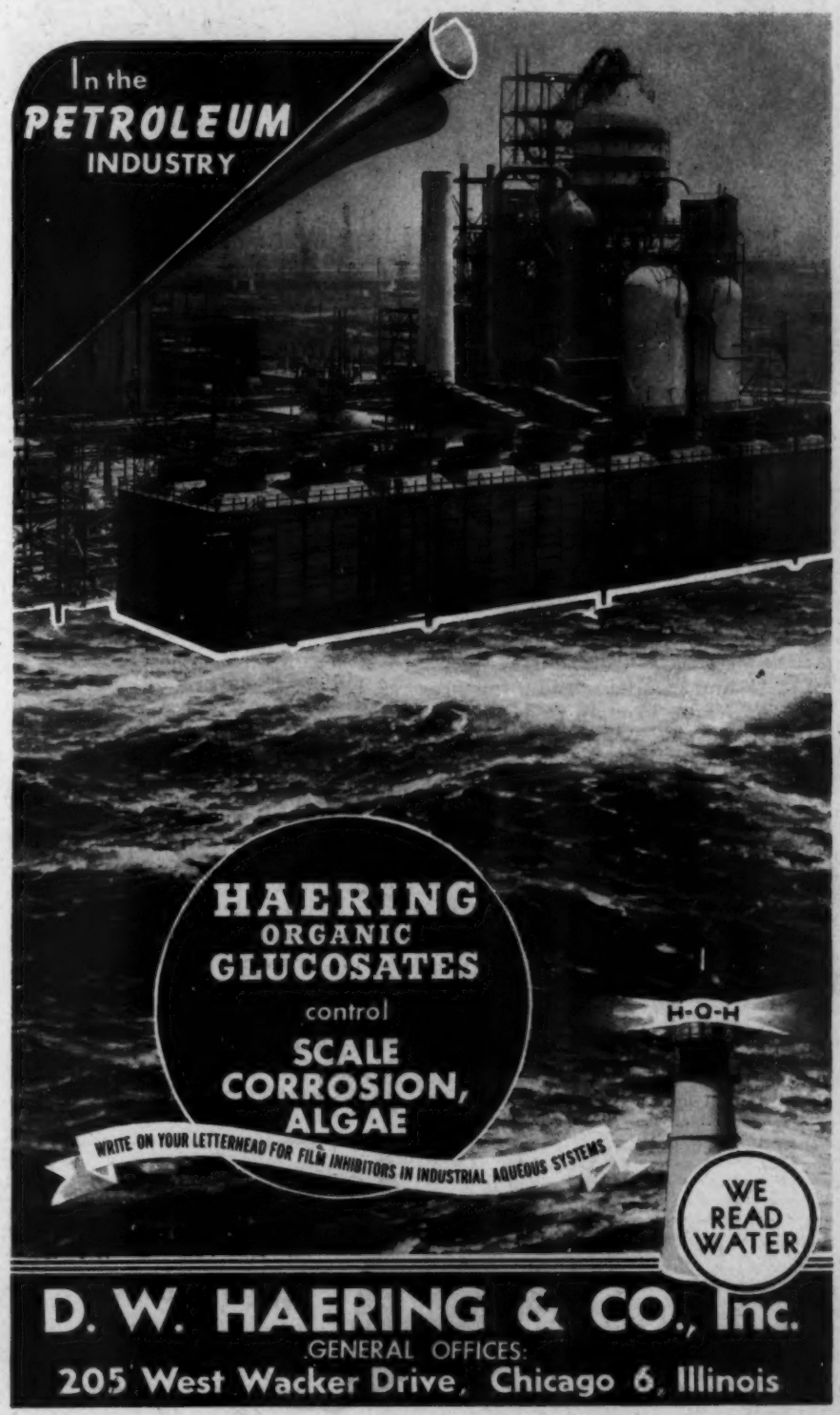
U.S.P. 2,425,414. Regeneration of Spent Caustic Solutions for Treating Gasoline. D. C. Bond to The Pure Oil Co.

Used Alkali solution containing mercaptides is regenerated by contacting it in the presence of a phenolic substance capable of promoting oxidation of mercaptans to disulfides with a mixture composed of oxygen and vapors of a low boiling normally liquid hydrocarbon which does not boil at regeneration temperature and pressure. The amount of oxygen shall be just sufficient to lower the mercaptide content of the solution sufficiently for its further use but insufficiently to irreversibly oxidize the catalyst. The vapors of the low-boiling hydrocarbon shall be present in the mixture in non-explosive proportions only. Pyrogallol is a preferred oxidation catalyst for the process. The added hydrocarbon, such as pentane, cyclopentane, or hexane, serves as a diluent to prevent or inhibit irreversible oxidation of the catalyst.

HEAVY OILS AND WAXES

U.S.P. 2,423,927. Constant Viscosity Hydraulic Fluid Compositions. R. E. Burk and E. C. Hughes to The Standard Oil Co. of Ohio.

Aromatic hydrocarbons, such as tolu-



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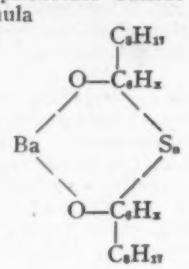
U.S.P. 2,424,204. Extreme Pressure Lubricants. J. C. Zimmer and J. G. McNab to Standard Oil Development Co.

The extreme pressure lubricant according to this patent comprises a major proportion of a mineral lubricating oil, a minor proportion (e. g. 7% by weight) of chlorinated paraffin wax preferably containing 40-60% Cl, at least a substantial proportion of which is in active form, and a still smaller amount (e. g. 1% by weight) of barium diisobutyl phenolate sulfide of the general formula



where n is 1 or 2 and x is a number satisfying valence requirements. This sulfide has a corrosion preventing influence.

U.S.P. 2,424,588. Lubricant Composition. W. J. Sparks and D. W. Young to Standard Oil Development Co.

The lubricant comprises a hydrocarbon oil of the gas oil to lubricating oil viscosity range containing dissolved therein an amount of about 1-30% of a linear polyester condensation product of a dimerized unsaturated long-chain aliphatic acid and a glycol. This condensation product shall have an average mol weight of at least 2000 and serves to improve the viscosity index of the lubricant. A condensation product of dilinoleic acid and decamethylene glycol can, for example, be used for this purpose.

U.S.P. 2,424,671. Process of Producing Oxidized Hydrocarbon Waxes. E. Stossel.

Substantially water-free crude oil is heated to a temperature at which the high m.p. waxes contained in the oil are dissolved. The oil is then cooled in the presence of asphaltic ingredients to a temperature at which substantially all of the high m.p. waxes and only a small percentage of the lower m.p. waxes contained in the oil are precipitated. A small percentage of an oxygen compound of chlorine, e. g. an alkali chlorate or a chlorite, is then admixed to the precipitate formed, and the thus obtained mixture is oxidized in the presence of an oxygen containing gas.

U.S.P. 2,424,956. Synthetic Lubricant. O. M. Reiff, H. D. Hartough, and H. J. Andress, Jr., to Socony-Vacuum Oil Co., Inc.

A synthetic lubricant of low pour point and susceptible of substantial pour point lowering is obtained from a crystalline paraffin wax melting not over 140° F. and a xylene by partially halogenating the wax to form a mixture of halogenated and unhalogenated wax with an amount of halogen correspond-

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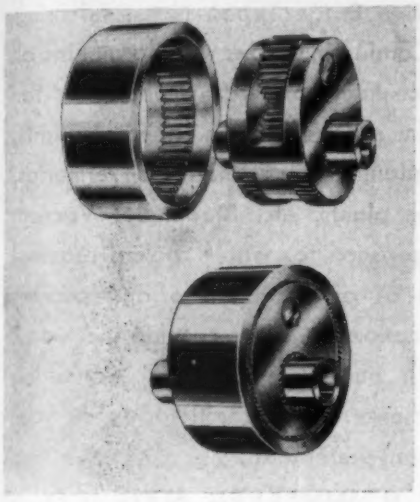


American Brake's Epicyclic Drive

1—Epicyclic Drive

Epicyclic drive, a simple and efficient means of converting high rotating speeds into slow reciprocating motion, built as an integral unit on anti-friction or plain bearings, depending on power requirements, has been announced by American Brake Shoe Company, 230 Park Avenue, New York 17. Test data on compressors and hydraulic pumps show greater efficiency than with more conventional methods of belting or gearing. Design of the drive permits considerable flexibility in both speed and stroke, making possible the use of built-in or direct drive input power where desirable in streamlining or packaging. Multiple units of different gear ratios and strokes may be mounted on a common power shaft. The drive is available for manufacture under license agreement.

2—Electrode

A new electrode for hard-surfacing applications where resistance to impact, wear, and abrasion is required has been announced by the Electric Welding Division of the General Electric Company. Designated Type W-94, the new electrode will work-harden to over 50 Rockwell C. It operates on a-c or d-c reverse polarity.

W-94 is available in 14-inch lengths, with diameters of ¼, 3/16, 5/32 and ⅛-inch. Address Schenectady 5, N. Y.

3—New Type Glycol

A new glycol, 2-methyl-1,3, pentanediol, a dihydric alcohol with an unusual structure, which is expected to find wide industrial use in soaps, detergents, softeners, and penetrants, in oils, hydraulic fluids, greases and lubricating oils, and as a plasticizer and coupling agent for resin solutions and printing inks, is offered to industry by Celanese Chemical Corporation, division of Celanese Corporation of America. Experimental quantities of this new glycol are now available for product evaluation, it was said. Address 180 Madison Avenue, New York 16.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

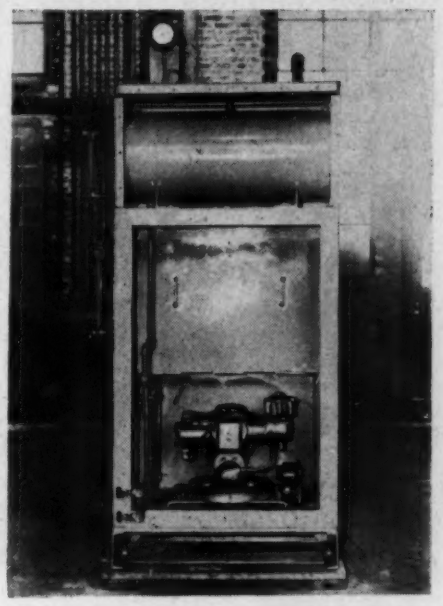
4—Respirator

A new respirator incorporating a revolutionary new dust filter for protecting industrial workers exposed to poisonous and disease-producing dusts smaller in diameter than 24 millionths of an inch is announced by American Optical Company, Southbridge, Mass.

The new filter consists of a felt which has been chemically treated so that its ability to prevent the passage of dust is 40 times greater than untreated filters.

Approved by the U. S. Bureau of Mines, the new AO R-2000 respirator and filter's increased efficiency is accomplished without a proportionate increase in breathing resistance. To prolong its life, the new filter is equipped with a gauze prefilter for catching larger particles of dust and dirt. The filter is easily changed.

American Optical's New Respirator



Interior of New Type Exhaust Waste Heat Boiler

5—Waste Heat Boiler

Fully self-contained and very compact, an exhaust waste heat boiler of an entirely new design has been developed by American Locomotive Company. Enclosed in an insulated steel cabinet only 6 feet, 6 inches long; 7 feet, 6 inches high, and 3 feet, 2 inches wide, the unit functions automatically on exhaust gases from a turbocharged Diesel engine, or it can be operated by household type oil burner.

The waste heat boiler generates 500 pounds of steam per hour on the Diesel exhaust and considerably in excess of that figure when operating on the oil burner. As a low-cost source of heat and hot water, the compact unit is unsurpassed, in the opinion of Alco engineers.

Address: 30 Church Street, New York 8.

6—Turbidity Recorder

A new turbidity recorder has been announced by Ess Instrument Company, which has been building these instruments on special order for a number of years. This new instrument comprises a viewing chamber through which the solution to be measured is passed, and attached to one end is a light source and the other a photo relay unit. The output from the photo relay unit is then connected to a potentiometer recorder which gives a continuous record of the condition of turbidity. The instrument may be equipped with warning lights or

NEW CATALOG

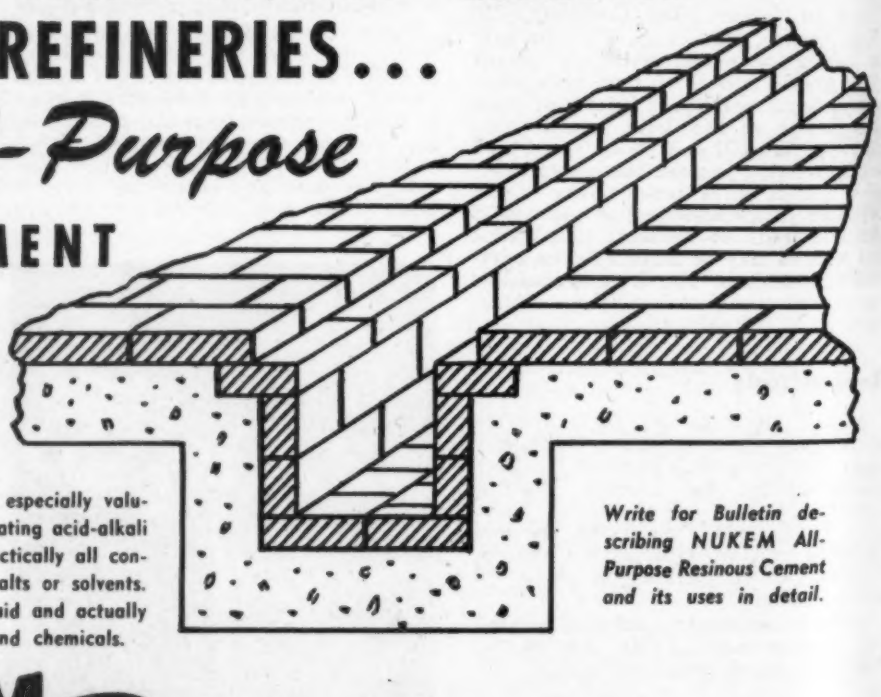
Theory and Operating Characteristics of Steam Jet Ejectors for all classes of vacuum service. Single, Two, Three, Four and Five Stage Types. Non-condensing and Condensing types with Barometric or Surface Inter- and After-condensers for vacuum requirements in chemical plants, food plants, sugar refineries, oil refineries, power plants, etc. Steam Jet Vacuum Refrigeration for water cooling requirements of air conditioning and process applications. . . . This catalog No. 1462 reflects our over 30 years' pioneering experience. Write for it today on your company letterhead.

C. H. WHEELER MFG. CO.
1818 SEDGLEY AVE., PHILA. 32, PA.
Representatives in most principal cities

STEAM CONDENSERS—WATER COOLING TOWERS—STEAM JET EJECTORS

THE PERFECT ACID-PROOF CEMENT FOR REFINERIES...

NUKEM *All-Purpose* RESINOUS CEMENT



Wherever a corrosive condition exists in a refinery, NUKEM All-Purpose Resinous Cement is the ideal jointing compound. Sewers, floors, pits, towers and tank linings last longer with no maintenance expense when this jointing compound is used.

NUKEM All-Purpose Resinous Cement is especially valuable where high temperatures and/or alternating acid-alkali processes are involved. It is immune to practically all concentrations of commercial acids, alkalies, salts or solvents. It gives excellent service when it is first laid and actually improves with age and exposure to heat and chemicals.

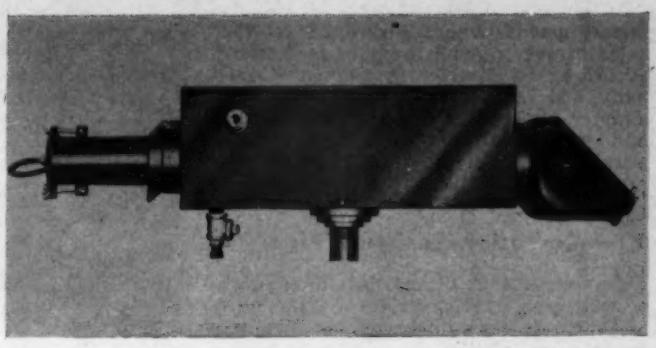
Write for Bulletin describing NUKEM All-Purpose Resinous Cement and its uses in detail.

NUKEM *Products* CORPORATION
115 COLGATE AVENUE, BUFFALO 20, N. Y.

electrical control points.

The instrument is available in range of 0 to 3 p.p.m., 0 to 50 p.p.m., 100 p.p.m., and up. The length of chamber used is a function of sensitivity and the range required.

Address 96 South Washington Avenue, Bergeafield, N. J., for Bulletin 604.

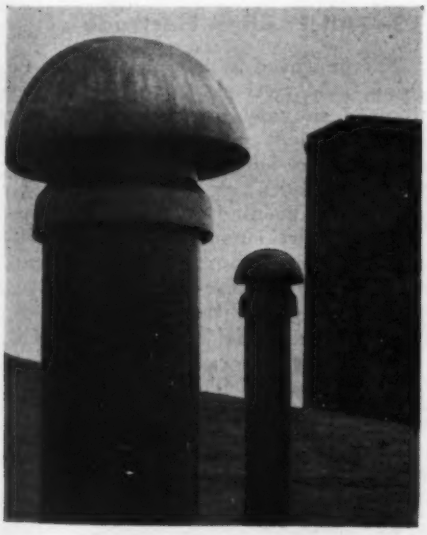


Ess Instrument Company's Turbidity Recorder

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

7—Clay Vent Cap

One of the more recent anti-lightning equipment developments is the clay vent cap designed by Robinson Clay Products Company 101 Park Avenue, N. Y., to slip over any bare vent or stack. The company points out that clay is a non-conductor and discourages the attack by lightning and that the vent is particularly adaptable to chemical plants or others where acid fumes are being discharged via vents or stacks. Clay is impervious to acids and will thus resist deterioration due to acid-bearing fumes, it is claimed.



Clay Vent Cap

8—Liquid Pump

Development and production of a "Twin-Line" high-pressure liquid pump, offering great flexibility in handling a variety of liquids at volumes up to 64,000 barrels per day and pressures up to 2000 pounds per square inch, has been announced by The Cooper-Bessemer Corporation, Mount Vernon, Ohio, and Grove City, Pa.

The "Twin-Line" design offers a comparatively large volume output and a great reduction in over-all weight and space through the application of high rotative speeds to opposed, short-stroke displacement plungers. The pump's normal speed of 400 rpm permits the economical use of a direct-connected prime mover in many installations, eliminating gear or belt speed reduction.

The pump is 7 feet 9 inches wide, 3 feet high, and varies in length from 4 feet 8 inches for the "Twin-Two," or 4-cylinder unit, to 9 feet 10 inches for the "Twin-Six." Weights range from 14,750 pounds for the "Twin-Two" to 27,750 pounds for the "Twin Six."

Accurate tests with a heavy grade of fuel oil show a volumetric efficiency of 95 percent minimum at 400 rpm with 1500-pounds-per-square-inch discharge pressure, and still higher efficiency at lower speeds and pressures. The mechanical efficiency is above 92 percent.

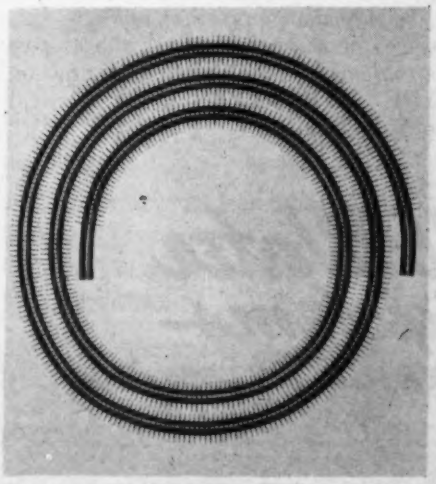
Descriptive bulletin upon request.

9—Finned Tubing

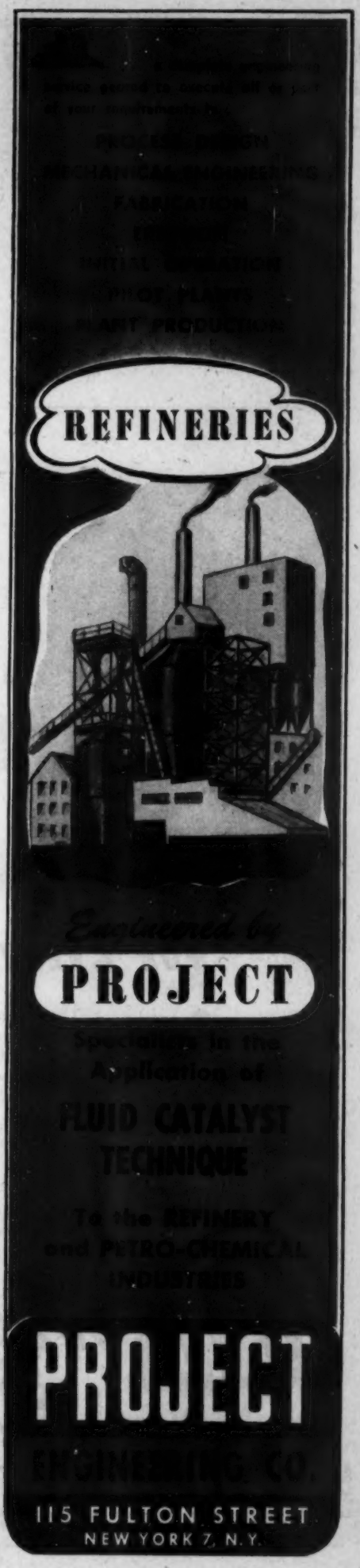
Coiled finned tubing of the recently developed serrated fin type has been made available for general industrial use by Fintube Coil Corporation, 19 West Main Street, Alhambra, Calif., under the trade name "Finco."

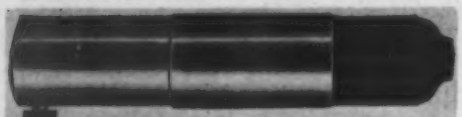
Utilizing a new bending technique, flat or pancake coils are now formed out of tubing with serrated fins as high as 5/8 inch without crushing or distortion of the fins.

"Finco" flat coils are now available in either ferrous or non-ferrous materials and in a wide range of tube sizes, fin heights, fin spacings and coil diameters.



Fintube Finned Tubing





Angle Adapter for Tachometer

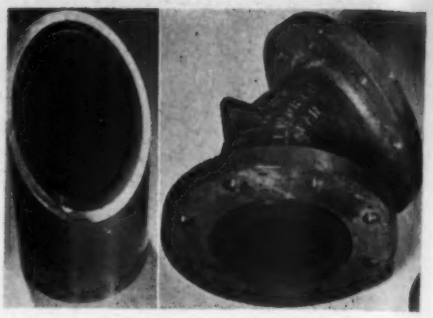
10—Tachometer Angle Adapter

Type 45 angle adapters for use with Metron hand tachometers, now available, permit the measurement of speed in cramped quarters where the clearance at the end of the rotating shaft is as little as 2 inches. They are also useful with the Type 61 disc for measuring linear speeds where clearance to the sides of the moving member is limited, according to Metron Instrument Company, 432 Lincoln, Denver 9. The angle adapter slips readily over the standard hand type head. Precision built, it consists of a pair of miter gears supported on permanently lubricated ball bearings.

11—Corrosion-Resistant Pipe

Announcement of the development of a new type of corrosion-resistant pipe and fittings was made by the plastics division of The Dow Chemical Company, Midland, Mich.

The product, Saran-lined steel pipe designed to convey corrosive liquids, combines the desirable features of steel pipe—rigidity and pressure strength—



Saran-Lined Pipe and Elbow

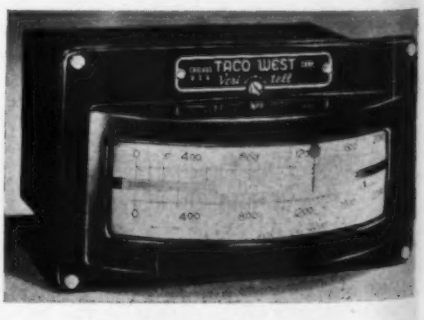
with Saran's extreme resistance to chemicals.

Saran-lined steel pipe is resistant to a wide range of chemicals, oils and solvents, including sulphuric, hydrochloric, nitric and phosphoric acids. The working temperature of the pipe ranges from 0° to 190° F.

Pipe in maximum lengths of 10 feet and in sizes from 1 to 4 inches will be manufactured. Fittings, also Saran-lined, include elbows and tees, companion and reducing flanges and gaskets. The latter are made of specially compounded Saran to assure maximum chemical resistance at joints.

12—All Position Electrode

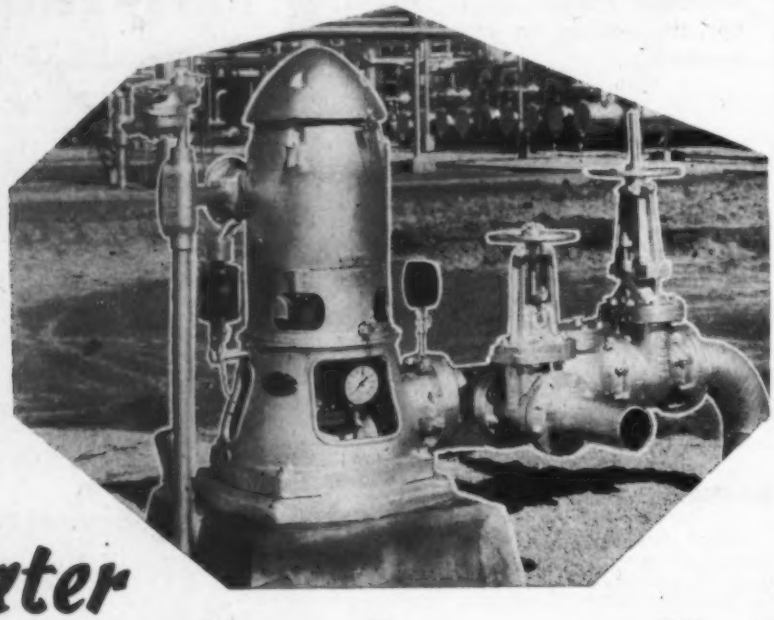
The improved Wilson No. 512 all-position, mild steel electrode is "designed to produce weld metal possessing not only excellent mechanical properties, but also low hydrogen content." It has two advantages over its predecessor in that it can be used on AC and DC reverse polarity current with the operating characteristics being equal; and preheating is no longer required to obtain porosity-free weld deposits that are obtainable by using either the stringer bead or the full weave technique. Address: Wilson Welder and Metals Company, Inc., 60 East 42nd Street, New York 17.



All-Position Electrode

13—Pyrometric Indicator

Taco West Corporation, 2620 South Park Avenue, Chicago 16, has announced addition of a new series of precision electrical indicators. Marketed under the trade name of "Veri-Tell" the line includes the Model "I," a millivoltmeter pryometric indicator thermally compensated, and including Briquet (thermostatic) automatic cold junction correc-



Water
FOR EVERY PETROLEUM NEED

● OIL FIELDS, REFINERIES, PUMPING STATIONS ●

The rugged in-built quality of Layne Well Water Systems and Vertical Turbine Pumps is no secret to the petroleum industry. This equipment is specifically engineered for the toughest water producing jobs. It is built to give longer life, operate at lower cost, and to produce more water per minute, hour, or day than any other made.

For the services of a representative; the answer to specific problems, or illustrated literature, address LAYNE & BOWLER, INC., General Offices, Memphis 8, Tenn.

LAYNE Well Water Systems
VERTICAL TURBINE Pumps

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. * Layne-Atlantic Co., Norfolk, Va. * Layne-Central Co., Memphis, Tenn. * Layne-Northern Co., Mishawaka, Ind. * Layne-Louisiana Co., Lake Charles, La. * Louisiana Well Co., Monroe, La. * Layne-New York Co., New York City * Layne-Northwest Co., Milwaukee, Wis. * Layne-Ohio Co., Columbus, Ohio * Layne-Pacific, Inc., Seattle, Washington * Layne-Texas Co., Houston, Texas * Layne-Western Co., Kansas City, Mo. * Layne-Western Co. of Minnesota, Minneapolis, Minn. * International Water Supply Ltd., London, Ontario, Canada * Layne-Hispano Americana, S. A., Mexico, D. F.

tion and the Model "H"—millivoltmeter pyrometric indicator which replaces the conventional Briquet cold junction compensation with the newly developed Hypar compensator which derives its operative energy from a convenient line supply.

Bulletin M-1 is available upon request.

14—CO_2 Fire Extinguisher

A new CO_2 extinguisher small enough to fit anywhere in a plant, provides on-the-spot fire protection. Only 15 inches long by 1⅞ inches in diameter, this small size Power-Pak unit comes equipped with a wall bracket. It weighs only 2 pounds, 6 ounces filled, including 10 ounces of carbon dioxide. Refills are available. Descriptive literature is available by writing Power-Pak Products, Inc., Buffalo 2, N. Y.

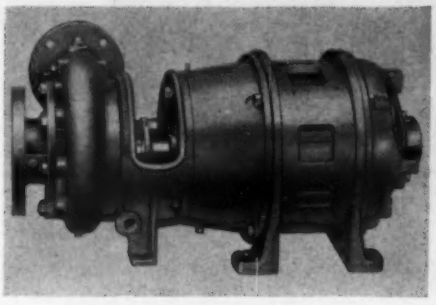
15—Airstarter

Bethlehem Supply Company of California, Box 3128, Terminal Annex, Los Angeles 54, has developed a line of "Air starters" to fit practically any make or model of multi-cylinder engine normally using electric starting. These starters are available in several sizes, and in the particular specifications required for any engine, and replace the conventional electric starter motor without any modifications of the engine.

In addition to the reduced fire hazard, the use of the "Airstarter" eliminates maintenance of storage batteries and their necessary charging apparatus.

16—"Close-Cupld" Pump

Goulds Pumps Inc., Seneca Falls, N. Y., has announced a new line of "Close-Cupld" centrifugal pumps. Pump and motor are combined on a single, compact assembly ready to install and operate in any position except vertically



Goulds' "Close-Cupld" Pump

with motor below pump. A single shaft eliminates a coupling.

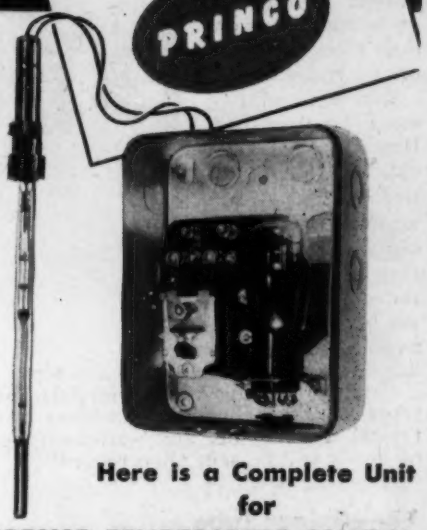
One of the new features is a machined stuffing box which permits the use either of a die-formed semi-metallic packing with lantern type liquid seal ring or a mechanical seal. The pumps are available in 17 sizes.

Ask for Bulletin 710-1.

17—Pipe Bending Machine

Pines Engineering Company, 601 Walnut Street, Aurora, Ill., has announced important innovations in its line of bending machines. Pines' installations in the

NOW— PACKAGED TEMPERATURE CONTROL by PRINCO



Here is a Complete Unit for
PRECISE TEMPERATURE CONTROL
from −60°C. to +300°C.

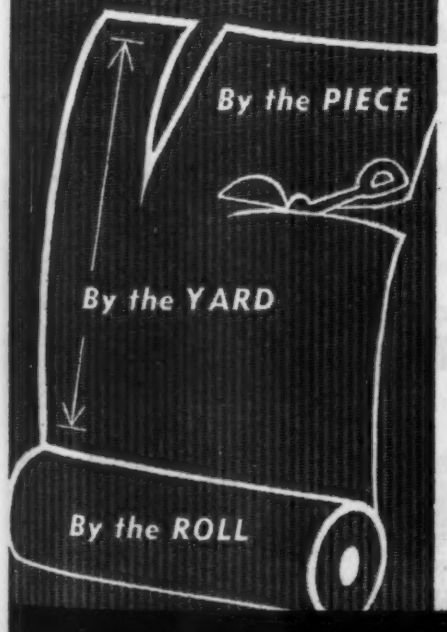
The famous PRINCO "Magna-Set" Thermoregulator and the PRINCO Supersensitive Electronic Relay

- ACCURACY—Control to within ±0.02°C. (to ±0.002°C. under ideal conditions).
- SENSITIVITY—Setting changes as slight as 0.005°C.
- CAPACITY—Loads up to 6 KW controlled by as little as 50 microamperes with single throw relay, and up to 3 KW with double throw.
- ADJUSTABILITY—Continuously adjustable within any 5°C. of entire range. Improved mercury trap for "rough" adjustment. Unique "micrometer" mechanism for final accurate setting.
- FLEXIBILITY — Available in "temperature rise to make," "temperature rise to break," or double-throw contact arrangements.
- CONVENIENCE—Everything in one "package"—ready to install.

Write for information and prices.

PRECISION
THERMOMETER & INSTRUMENT COMPANY
PRINCO
PRECISION INSTRUMENTS FOR INDUSTRY
1417 Brandywine Street, Philadelphia 30, Pa.

MULTI-METAL WIRE CLOTH



For more than 35 years, scores of industries have looked to Multi-Metal for wire and filter cloth of every description. Through constant experimentation, many exclusive types have been developed that speed output by improving the efficiency of processing equipment and restoring the usefulness of worn out units. As a result, Multi-Metal maintains one of the nation's most extensive stocks of metal cloth.

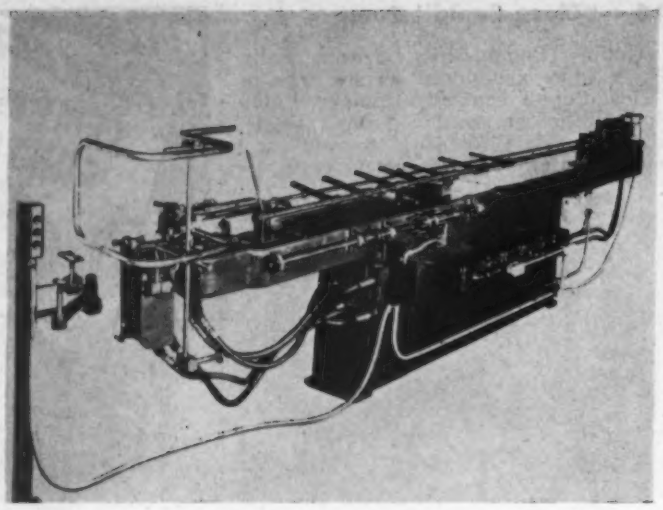
Wire cloth is supplied by the piece, yard, or roll. Send for free catalog and wire cloth sample, or mail a sample of the cloth you are now using for immediate quotations.

All meshes, all weaves, all metals. Also, wire cloth in fabricated units.

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

metal furniture field are producing up to 800 bends per hour average, this largely due to finger-tip control and built-in adjustments which permit single duplication of a series of various bends on each piece throughout an entire lot.

Inherent adjustment features of Pines Benders provide a rapid, positive means to set up each job and to control the accuracy of the bends in the finished product. A full range is available which handle up to 6-inch extra heavy pipe.



Pipe-Bending Machine

Catalog showing various models and types of Pines bending machines and typical applications and various types of bends will be sent upon request.

18—Geiger Tube

A new, multi-purpose, self-quenching Geiger tube for use with beta, gamma and soft X-radiation has been announced by North American Philips Company, Inc., New York.

The new tube is rugged and employs an extremely thin mica window which is vitreous-sealed to the main tube body. It is said to represent an advanced design especially suited to tracer, survey and X-ray spectrometer work.

The tube may be used for tracer work employing C^{14} for soft X-radiation and for operations involving radium. Used with suitable circuits, it is capable of handling in excess of 3000 discrete counts per second. Address 100 E. 42nd St., New York.

19—Nylon Filter Cloth

Filter Media Corporation, Hamden 14, Conn., announces the availability of nylon filter cloth. This nylon cloth is substantially inert to most common alkalis, most organic acids, alcohols, etc., and has exceptionally high abrasion resistance, excellent heat resistance (melting point approximately 482° F.), is unaffected by fungi and micro-organisms, and has an extremely smooth surface which greatly facilitates cake discharge.

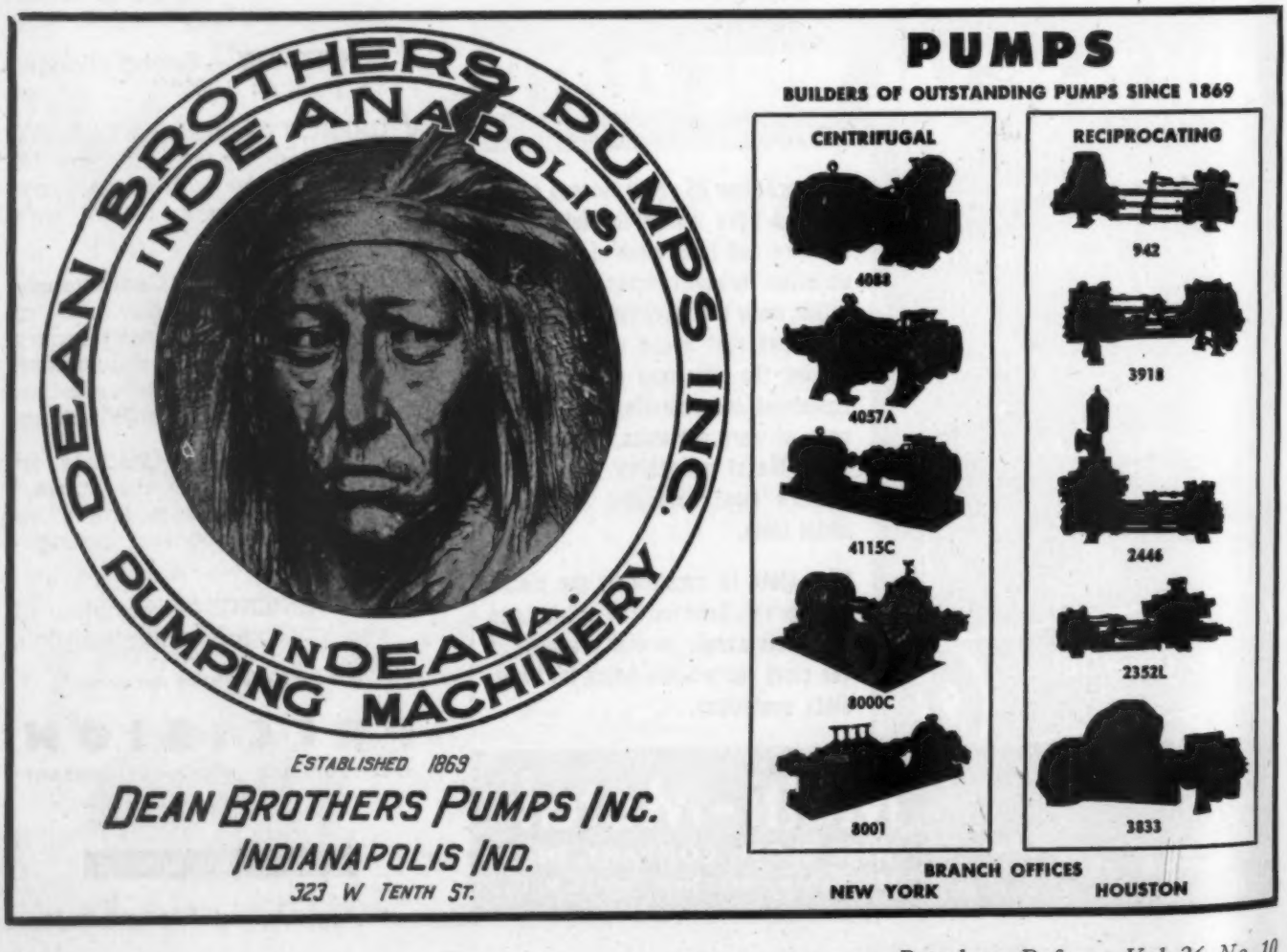
Literature and pilot test samples are available on request.

20—Pressure Gauge

A pressure gauge constructed for handling corrosive substances features a lathe turned beryllium copper bourdon tube, with beryllium copper locktite cones screwed at the tip and socket. The tip and socket are made from brass bar stock. It has a special bronzed bushed movement with bronze pinion and arbor and can be furnished in several case styles and dial sizes.

Known as the type 105 Mastergauge, this unit is recommended for alcohol

Marsh Pressure Gauge



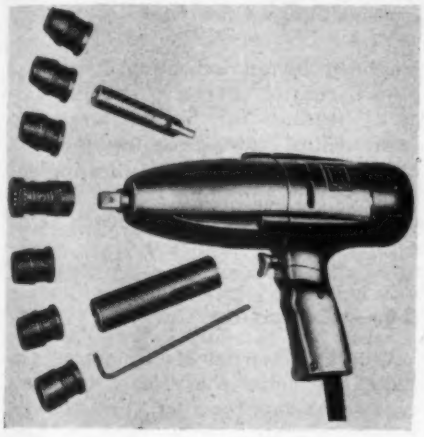
(ethyl, menthol, propyl), sodium acid sulphate, sodium chloride, oxalic acid (cold), carbon tetrachloride, paper mill sulphite solutions, boric acid, sulphuric acid (cold), alum solutions and hydrogen sulphide.

Jas. P. Marsh Corporation, 2073 Southport Avenue, Chicago 14.

21—Electric Impact Tool

Ingersoll-Rand Company, 11 Broadway, New York 4, announces a new universal electric, all-purpose impact tool which, using standard attachments, will apply and remove nuts, drill, ream, tap, drive and remove screws, drive and remove studs, extract broken cap screws and studs, run wire brushes, do hole saw work, drill brick and masonry, drive wood augers, etc.

Designated as Size 4U, the machine



Ingersoll-Rand Impact Tool

weighs 6½ pounds, has an over-all length of 10½ inches, a free speed of 2000 rpm, and delivers 1900 rotary impacts per minute under load. It is powered with a specially designed reversible, universal, electric motor (3 amp.) that operates on 110 Volt, AC-DC current.

One advantage of the impact mechanism is that it permits the spindle to be stalled completely while the motor continues to run thus eliminating motor burn-outs caused by overloading. It also eliminats torque reaction to the operator.

Bulletin 5030 describes the item.

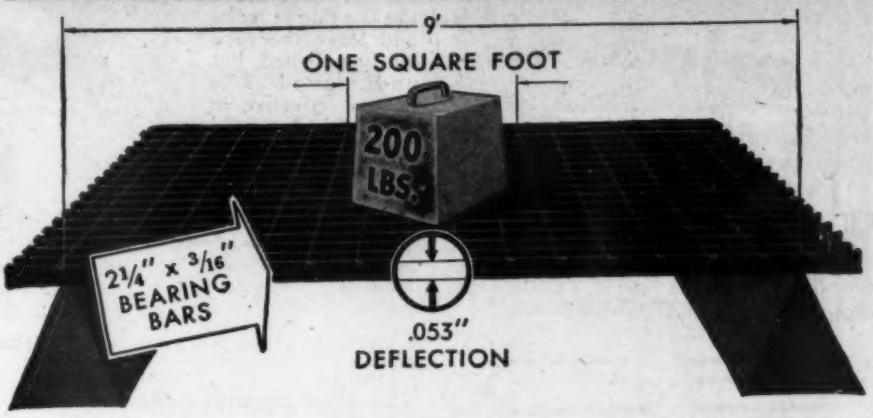
When writing the manufacturer of new equipment for literature or more information identify his product by name and number listed in Petroleum Refiner.

22—Cutter Head

The Lagonda Division of Elliott Company, Springfield, Ohio, announces a new improved all-purpose tube cleaner cutter head, the 3300 series long-surface swing-frame head. The new design features a non-threaded cutter pin and increased cutter surface.

The swing-frame type of cutter head consists essentially of a spider with arms swinging out on arm pins under centrifugal force. Its one disadvantage —the threaded cutter pin—has now been eliminated. The new head uses, instead

This is **TRI-LOK**
OPEN STEEL FLOORING



The locked in strength of TRI-LOK enables it to stand up under heavy loads—even on long spans. No rivets, bolts or welds are used in its construction, thus, the possibility of loose joints is eliminated. *Write for Bulletin 1140.*

DRAVO CORPORATION
NATIONAL DEPARTMENT
1103 Pitt Bank Building, Pittsburgh 22, Pa.
(Distributor for THE TRI-LOK COMPANY)

DRAVO

● **This Petroleum Refiner CLASSIC**
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By V. O. MARSHALL, Chief Engineer, J. P. Devine Manufacturing Company, Inc.

With the years there has been no let-up in the demand for this article which was published in the August, 1943, Petroleum Refiner. Sufficient reprints are again ready to accommodate the needs of engineers both in and out of the refining industry.

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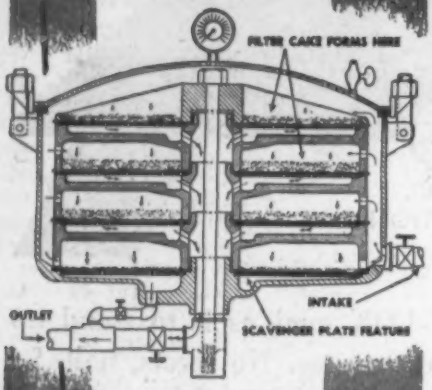
the horizontal plate principle



. . . makes these the "filters that filter all liquids"—

SPARKLER
Horizontal Plate
FILTERS

. . . and here's the story:

- Sparkler Horizontal Plate Filters handle any liquid from heavy varnishes to light alcohols, including products such as acids, oils, beverages, milk, pharmaceuticals, plating solutions, water, etc.
- Equally efficient performance on intermittent or continuous operation, under a wide range of temperature, pressure and viscosity conditions.
- Equally effective whether removing carbons and contact clays or clarifying and polishing with filter aids.
- Patented Scavenger Plate permits complete batch filtration. (It's virtually an auxiliary filter with an independent control valve.)
- Unexcelled filter cake stability—no slipping or breaking.

. . . why?

Because filter media are supported on a horizontal plane and filter aids floated into position uniformly, filtration takes place uniformly over entire filtering areas. Flow through filter is always *with* gravity.

Sparkler Filtration Is *Engineered* Filtration—we invite correspondence on your problem. You will receive the advice of filtration scientists with a quarter of a century of experience in a specific field.

SPARKLER MANUFACTURING CO.
MUNDELEIN, ILLINOIS

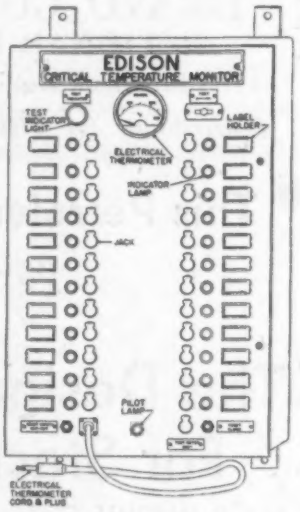
of a thread, a small piece called a "keeper," which fits in a slot in the arm and locks into a groove in the cutter pin. The head is heavy and "wicked" enough to remove the hardest coke and leave the tube nicely polished, but undamaged. The head is effective in both light and heavy scale.

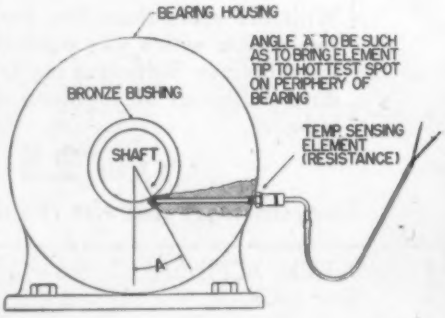
The long-surface swing-frame head is being built in seven sizes, accommodating the size range from 2¼ inch to 6 inch i.d. tubes.

Elliott Company's Cleaner Cutter Head

23—Temperature Monitor

To warn when bearings start overheating is the function of an automatic, multi-point bearing temperature monitoring system developed by the Instrument Division of Thomas A. Edison, Incorporated, 52 Lakeside Avenue, West Orange, N. J. The system is adapted to




BEARING HOUSING
ANGLE A TO BE SUCH AS TO BRING ELEMENT TIP TO HOT TEST SPOT ON PERIPHERY OF BEARING
BRONZE BUSHING
SHAFT
TEMP. SENSING ELEMENT (RESISTANCE)
A

principal equipment and auxiliaries in power generating stations, gas plants, pipe line substations, and general industrial operations.

Each bearing is checked automatically every two minutes. If, when checked, any bearing is too hot, an alarm is sounded. The overheated bearing is identified by an indicating lamp on a central control cabinet panel. As many as 24 bearings can be monitored from each central control cabinet.

The temperature of each bearing may checked at any time with a panel-mounted electrical thermometer at the central control cabinet.

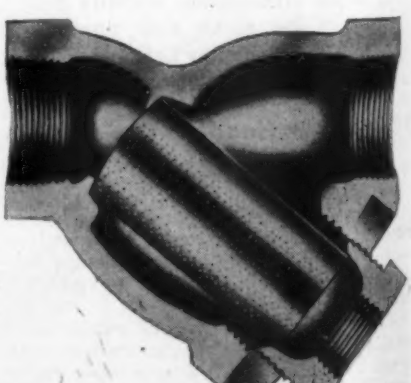
24—"Capacilog"

Wheelco Instruments Company, Chicago, announces the release of a new type strip chart recorder, the Capacilog, which "operates on a Wheelco Electronic Principle, so successfully applied to the company's Capacitrol pyrometer controller for many years."

Simplicity of operation without amplification, physical contact or disturbance in the measuring circuit (no relays—no converters) results in accurate and instantaneous response, the company states.

25—Y-Type Strainer

A new Y-Type Strainer for steam, air, gas, oil or water is announced by Wright-Austin Company, 315 West Woodbridge Street, Detroit 26, Mich., who claim that this strainer largely overcomes back pressure through a new arrangement of interior surfaces, guiding liquids or gases on a course unob-



Y-Type Strainer

structed by sharp corners or abrupt changes in path of flow.

The manufacturer states that strainers are self-cleaning by opening of blow-off cock, which flushes grit and dirt out of strainer by line pressure, without shutting off the line or removing the strainer elements.

These strainers are suitable for use on working steam pressures up to 250 psi. and temperatures up to 450° F. For use on cold liquid lines or gas lines the pressure rating is stated as 400 psi.

26—New Organic Chemicals

Iso-and tere-phthalic acids and rare aldehydes such as capryl aldehyde are among the new organic chemicals recently developed by the Genesee Research Corporation, 577 Lyell Avenue, Rochester, N. Y. The addition of these makes a total of more than 40 rare organic chemicals which this company now has available in research and pilot plant quantities. A list of chemicals will be sent upon request.

27—Steam Specialties

Bulletin CI-47 on steam traps, steam separators and other steam specialties has been announced by Wright-Austin Company, 315 West Woodbridge Street, Detroit 26. Described are three types of Cub "AIREXPEL" steam traps and also included are two types of strainers, safety gauge glass protectors and air relief valves.

28—Wrought Iron

An illustrated booklet that describes wrought iron has been made available by A. M. Byers Company, Pittsburgh. The title is "The ABC's of Wrought Iron." The booklet tells why wrought iron resists corrosion and withstands shock and vibration, how it is made, and how it is bent, welded and threaded.

29—Pressure Controls

Bulletin S-17 issued by The Swartwout Company, 18511 Euclid Avenue, Cleveland 12, Ohio, illustrates and explains a new series of precision differential pressure master controls; includes hook-up diagrams illustrating a number of application examples.

30—Thermal Conductivity Units

Gow-Mac Instrument Company, Newark 5, N. J. has issued a bulletin "Gow-Mac Ever-Tite Thermal Conductivity Units" which illustrates by photographs and sketch "the instrument of a thousand uses." In addition to this instrument "for low-cost gas analysis, several other of the company's items are pictured.

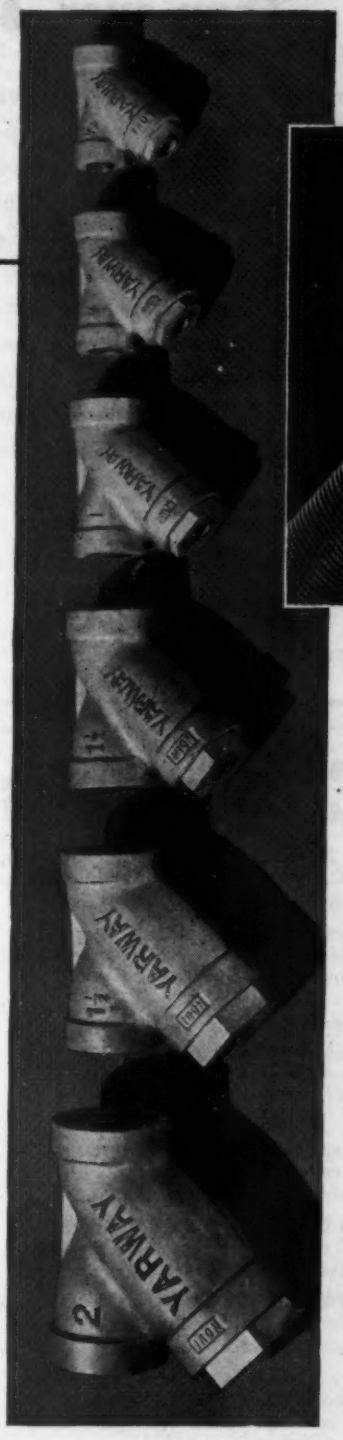
31—Welding Fume Exhauster

The new M.S.A. portable welding fume exhauster, designed for use in welding operations where stationary ventilating systems are unavailable or impractical, is described in Bulletin CU-1 published by Mine Safety Appliances Company. It is especially suited for operations in cramped, confined quarters

PREVENT

Rust·Scale·Dirt

FROM CLOGGING STEAM EQUIPMENT



YARWAY

STRAINERS

"The Screen's the Thing"

- *A High Grade Monel Woven Wire Basket* with mesh fine enough to catch the dirt—yet ample free area for passage of clean condensate, oil and other fluids.
- *Body Cadmium plated for protection against corrosion and for better appearance.*
- *Readily Removed Steel Blow-Off Bushing.*
- *Bushing Automatically Aligns Screen.*
- *Thousands in Use—Sold by Nearly 150 Mill Supply Houses.*
- *6 Sizes ½" to 2" for Pressures up to 600 lbs.*

See Your Supply House or write for Bulletin S-201

YARNALL-WARING COMPANY

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YARWAY STRAINERS

21st

Exposition of Chemical Industries

DEC. 1-6

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BIGGER . . . BETTER ! than ever !

An unequalled opportunity to see and learn about the latest developments in materials, methods and equipment for all phases of chemical processing . . . new ideas for cutting costs, increasing production and improving products . . . first-hand technical assistance on present problems and future plans. Anyone engaged in or associated with any phase of the chemical industries will benefit by attending.

PLAN TO ATTEND

Bring Your Associates

You'll say, "time well spent"

Refinery Engineers

There are excellent career opportunities in SOUTH AMERICA! An American oil company affiliated with Standard Oil Co. (N. J.) is expanding operations and has openings for qualified graduate engineers:

SENIOR ENGINEER: Graduate Mechanical Engineer with 10 years' experience in refinery mechanical department organization, including equipment design, corrosion problems, and capital budget makeup.

MAINTENANCE & CONSTRUCTION SUPT: Must have 5 years experience supervising construction of major refinery projects; must know refinery materials and equipment and established engineering practices involved. Indirect supervision all work performed by mechanical crafts.

EQUIPMENT INSPECTOR: 5 years refinery experience with substantial equipment inspection experience involving familiarity with all refinery equipment and established codes of construction.

ASS'T. PROJECT ENGINEER—PROCESS UNITS: 4-5 years experience supervising contractor erection of refinery process units. Primarily familiar with design. Secondarily familiar with operation.

ENGINEERS—TECHNICAL SERVICE DEPARTMENT: ME's, Ch. E's, EE's: 4-5 years refining experience required with substantial experience as engineer on maintenance and construction.

CHEMICAL ENGINEER: 5 years lab operating or technical work in refinery. Assigned to Chem. engineering problems and refining processes. Must have wide practical experience. Background in accepted chemical engineering practices.

Liberal salaries—other cash allowances—generous savings and retirement plan—paid vacations in the U. S. plus travel expenses—excellent chances for promotion.

Write us telling of your age, education and experience. Your letter will be held strictly confidential.

CREOLE PETROLEUM CORPORATION

Division D, Empire State Bldg., New York 1, N. Y.

or where the welder must move from place to place in enclosed areas.

Weighing only 25 pounds, and 34 inches long by 10 inches in diameter, the exhaust is completely self-contained.

Write to Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, Pa.

32—Packings

A new catalog section on its lines of packings has been published by The B. F. Goodrich Company, Akron, Ohio, and is now available upon request. The section describes and gives data on various types of its Super-heat compressed asbestos sheet packing, rubber sheet packing, cloth inserted packings and Koroseal sheet packing.

33—Low Air Pressure Burner

Bulletin 65, National Airoil Burner Company, Inc., 1284 E. Sedgley Avenue, Philadelphia 34, deals with Type LAP, Model SC low air pressure oil burner and airovent centrifugal blowers. This type burner uses low pressure air for atomization, for firing process furnaces of all types with light or heavy fuel oil under manual or automatic control. Photos, schematic drawings, tables, etc., are used in making the presentation.

34—Floating Roof

Wiggins Hidek floating roofs are described in General American Transportation Corporation's new booklet. Single and double seal models with reports on evaporation, standing and pumping losses are graphically portrayed, the cut-away illustrations being particularly effective. "Blueprints" also are shown. Address 135 South LaSalle Street, Chicago.

35—Seamless Metal Hose

Bulletin 20-C of Atlantic Metal Hose Company, Incorporated, shows the several types of flexible metal hose which are now manufactured by this firm in bronze, steel and monel. The company's "bellows" construction, depicted in sectional photographs, are given special treatment. Address 123 West 64th Street, New York.

36—Centrifugal Pumps

Ingersoll-Rand Company, Phillipsburg, New Jersey, has issued Form 7134, a bulletin, which gives details of its Cameron Motorpump for bulk station use. Features of the unit are described in simple text and there are sectional drawings as well as installation views for ilustrations.

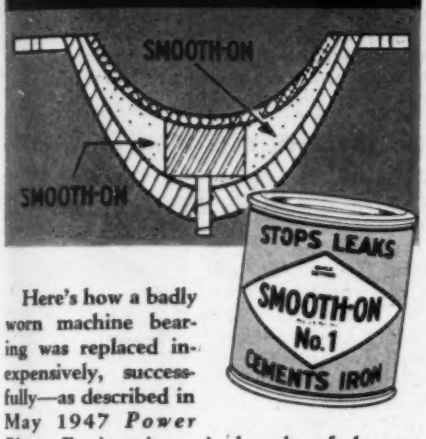
37—Molecular Distillation

Distillation Products, Inc., Rochester, N. Y., has issued a booklet which describes in some detail their process of molecular distillation as well as their laboratory molecular stills. Various diagrams of processes and equipment as well as photographs are included.

38—Air Heater

The Babcock & Wilcox Company, 85 Liberty Street, New York 6, has published a 16-page bulletin, which gives information on its tubular air heater.

This BEARING REPAIR worked fine...cost little



Here's how a badly worn machine bearing was replaced inexpensively, successfully—as described in May 1947 *Power Plant Engineering*. A length of bronze bearing stock, a piece of 1½-inch key stock and some Smooth-On No. 1 Iron Cement were all the repair men used.

They split the bearing stock in half and cut it the length of the worn bearing. Then they cleaned the old metal out of the bearing case, and positioned a half bearing along the top of a similar length of key stock.

Finally, they filled up the spaces all around with Smooth-On No. 1. When this had hardened, the machine was put back in service. Ten months later, the bearing was reported still "working fine."

For the past 52 years, engineers, mechanics and repairmen have been depending on Smooth-On No. 1 for emergency and routine repairs such as this. It will pay you to keep Smooth-On No. 1 handy. Order it in 1-, 5-, 25- or 100-lb. size from your supply house. If they haven't it, write us.

FREE 40-PAGE REPAIR HANDBOOK

Filled with practical, time-saving, money-saving uses for Smooth-On No. 1 and other special Smooth-On Cements. Leaks stopped. Cracks sealed. Loose parts tightened. Clear directions. 170 diagrams. Handy pocket size. Get YOUR free copy—just mail the coupon.

— — — *Sign and Send This NOW* — — —

Smooth-On Mfg. Co., Dept. 11K,
570 Communipaw Ave., Jersey City 4, N. J.
Please send me MY Smooth-On Handbook

Name .....

Address .....

10-47 .....

Do it with SMOOTH-ON
Iron Cement of 1000 Uses

Positive identification of new equipment bulletins by name and number listed in Petroleum Refiner insure prompt replies to your requests for literature and information.

Both the economics and the engineering factors involved in the selection of air heaters are considered and various types of construction are presented. Charts and tables are included for the several technical considerations necessary in the application of air heaters.

39—Laboratory Instruments

Chart R-1066 titled "Basic Characteristics of Useful Industrial Laboratory Instruments" may be had from North American Philips Company, Inc., 100 East 42nd Street, New York. Vertical columns have the following headings: Apparatus or System, Principle, Basic Arrangement, Operation, Application, Comments, and Manufacturers or Suppliers. Instruments covered in the tabulation and include: colorimeter, cyclograph, electron microscope, geiger-counter, X-ray spectrometer, magnaflux, mass spectrometer, photometer, photelometer, spectograph, spectrophotelometer, spectrophotometer, X-ray diffraction, zyglo, electron diffraction and supersonic.

40—Gas Alarm System

Davis Emergency Equipment Company, Inc., Halleck Street, Newark, New Jersey, has issued Technical Bulletin 1142, which describes its combustible gas alarm system for detection of flammable gas or vapor air concentrations.

It includes a schematic diagram, which shows the relationship of the units of a design with remote head.

41—Mechanical Drive Turbine

Elliott Company, Jeannette, Pennsylvania, has published Bulletin H-16, which gives details of its new YR mechanical drive turbine. In addition it gives a brief history of the development of turbines of this type. It contains complete general and materials specifications of the Elliott turbine and notes ten modifications to standard turbines and the six types of governors available.

42—Air Filters

American Air Filter Company, Inc., Louisville, Ky., has issued its Bulletin No. 210 describing selective air filtration offered by replaceable type air filters including "throway," type G "drifilter" and "renu-vent." Engineering and installation data are included.

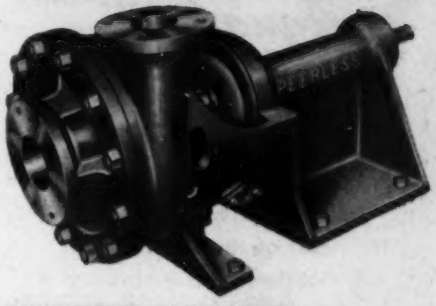
43—Liquid Level Indicators

Yarway bulletin WG-1821 on remote liquid level indicators has been replaced by WG-1822, Yarnall-Waring Company, Philadelphia, has announced. Compensator description and control of unit and its attachments are featured. Construction and installation details as well as many photographs are included.

REFINEMENTS IN PUMP DESIGN REDUCE COSTS OF PUMPING CORROSIVES

Compare the pumps presently handling your corrosives with the Peerless Type ACO, especially developed for pumping acids and caustics. The Type ACO is a single stage, single suction pump with the volute and drip pocket cast integral, of special alloys to suit the solution being pumped. Bronze, stainless steel, Monel, NI-resist can be furnished. Stuffing box is long and extra deep with special opening affording easy accessibility. Drive is electric motor through flexible coupling. Capacities up to 800 g.p.m. can be handled against heads to 200 feet.

PEERLESS PUMPS
PEERLESS TYPE ACO PROCESS PUMPS FOR ACIDS · CAUSTICS



VENTED VOLUTE: Special passage vents into discharge. Eliminates conventional screwed valve which often corrodes.

DRIP POCKET DRAIN: A flange and two bolts which can be made of stainless steel replaces screw type fitting ordinarily used for this purpose.

VERTICAL SPLIT: Utilizes one piece circular gasket; easier handling and replacement assured by this design.

INBOARD END CAP: Special alloy cap prevents liquid passing water slinger into bearing housing.

NEW BULLETIN: Fully describes and illustrates these and additional refinements in Type ACO design. Write for Bulletin D-2400.

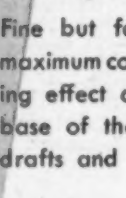
PEERLESS PUMP DIVISION
FOOD MACHINERY CORPORATION
Factories: Los Angeles 31, Calif.; Quincy, Ill.; Indianapolis, Ind. *District Offices:* Chicago 40, 4554 North Broadway; Philadelphia Office: Suburban Square, Ardmore, Pa.; Atlanta Office: Rutland Bldg, Decatur, Georgia; Dallas 1, Texas; Los Angeles 31, California.

BLAW-KNOX
Aquatomic
FOG NOZZLES
DO NOT FAIL!

Wide clear passages through the heart of this dependable Fog Nozzle makes it virtually non-clogging—always reliable.

It fights fire with the water available—maintains its fog pattern under low pressures in emergency.

Fine but forceful fog gives maximum cooling and quenching effect and drives to the base of the fire in spite of drafts and turbulence.



Also—

Blaw-Knox offers Standard Wet and Dry Pipe Systems, as well as Thermostatically Controlled Pre-Action and Deluge Systems.

Write for details.

BLAW-KNOX
SPRINKLER DIVISION
832 Beaver Avenue, N.S.,
Pittsburgh 12, Penna.

About EQUIPMENT—SERVICE Suppliers

West Coast Manager Announced by Tube Turns

Jack Green, sales manager of the welding fittings division of Tube Turns, Inc., Louisville, Ky., has announced appointment of Lewis M. Bound, Jr., as West Coast manager, with headquarters in San Francisco. Bound, who assumed his new duties September 1, is a native of Independence, Kans., and attended high school in Braintree, Mass., Thayer Academy, and Purdue University. He joined Tube Turns' New York office sales staff in July, 1941. During his three years in the Army, he served in the Field Artillery in Europe.

Bound

Rheem Building New Plant at Canadian Site

Rheem Manufacturing Company has organized a subsidiary company in Canada, to be known as Rheem Canada, Limited, with offices and plant at Hamilton, Ontario. R. S. Rheem will be president. Other officers are Trumbull Warren, vice president and general manager; Ronald L. Marks, secretary-treasurer; E. L. Prais, production manager.

Rheem Canada, Limited, will manufacture steel shipping containers for the petroleum, chemical, and other industries. Other products similar to those made by Rheem plants in the United States later will be added.

The plant of Rheem Canada, Limited, is the eighth built outside the United States. Five of these plants are located in Australia, one in Singapore and one in Rio de Janeiro.

Glycerine Tank Cars

Shell Chemical Corporation of San Francisco has ordered 36 new all-aluminum tank cars, according to American Car and Foundry Company. The cars to be used in the transportation of synthetic glycerine. The tanks, each of 8000-gallon capacity, will be of all-welded construction and will be built at the ACF Milton, Pa. plant.

Belgium Recovery Noted By U. S. Company Head

Belgium, unhampered by burdensome government controls, appears to be making more progress on the road to recovery than any wartorn European country, Harold W. Sweatt, president of Minneapolis-Honeywell Regulator Company, said on his recent return from Europe.

In Europe Sweatt attended a session of the company's European managers in London. Heads of subsidiaries in Zurich, Stockholm, Amsterdam, Brussels and London attended the meeting which was called to discuss general European operations of the company. Although the importation of heating controls is largest in Sweden, the demand for industrial instruments from the company's subsidiary, the Brown Instrument Company, has been most noticeable in Belgium where activity in the steel and chemical industries is heaviest, Sweatt said.

De Laval District Manager

Harvey A. Mylander has been appointed district manager for Southern California and Arizona for the De Laval Steam Turbine Company, Trenton, N. J. Mylander formerly was associated with General Electric Company and American Hoist and Derrick Company. Previously he spent several years as sales engineer for the International General Electric Company in Venezuela.

Mylander

Headquarters for Mylander and Robert D. Doepken, sales engineer, will be maintained at 124 West Fourth Street, Los Angeles, Calif.

Climax Engineering Company Controls Division at Tulsa

The physical assets of Climax Industries, Inc., both at Tulsa, Okla., and Clinton, Iowa, have been purchased from General Finance Corporation (owner of Climax Industries, Inc.) by Liberty Products Manufacturing Company, Inc., which is a wholly owned subsidiary of Smith Engineering Company, Kansas City, Mo. The stock of Climax Industries, Inc., was not purchased. The purchase was effective as of July 1, 1947.

The new activity will be operated under the name of Climax Engineering Company, the Tulsa plant being designated the Controls Division—an independent division of Liberty Products Manufacturing Company, Inc. Climax Engineering Company, Controls Division, at 15 North Cincinnati, Tulsa 1, Okla., will continue to produce the complete line of products formerly known as McAlear "H" items (and at one time known as Hanlon-Waters products).

Brown Adds to Branch Engineering-Sales Staffs

Brown Instrument division of Minneapolis-Honeywell Regulator Company has announced personnel changes as follows:

Edward B. Kohl transferred to Corpus Christi, Texas from Houston.

I. K. Farley transferred from Philadelphia to Houston.

John D. Root, formerly instructor at the Brown School of Instrumentation, made sales engineer at Philadelphia.

E. Curt Richards transferred from

the general sales department to the New York sales engineering staff.

Thomas Pitts appointed industrial sales engineer at Charlotte.

Added to the company's branch office field service engineering staffs: William E. Brittain, Philadelphia; Edward J. Chance, New York; Ethron B. Deebel, Philadelphia; Gerald R. Dryden, Syracuse; John W. Forbes, Albany; Carl R. Haug, Philadelphia; Willard A. Holm, New York; Roger F. Lederer, Chicago; Albert J. Leonaitis, Hartford, Conn.; Elgin H. Lochte, Houston; John E. Luttrell, Buffalo; Kenneth Shapleigh, Boston; Clayton K. Taylor, Indianapolis; Robert H. Walker, Cleveland, and Frank M. West, Boston.

Tatkin Advertising Manager Of Vapor Recovery Systems

Albert Tatkin, formerly with The McCarty Company of Los Angeles, has been appointed advertising manager of Vapor Recovery Systems Company, Compton, Calif. He will be in charge of the company's advertising and sales promotion and will assist in sales engineering.

Tatkin

Tatkin is a graduate petroleum engineer from the University of Minnesota. For the past year and a half, he has been employed as an account executive at The McCarty Company. During the war, he served as a captain in the Air Corps. Prior to his army service, he was associated with Western Geophysical Company.

Oakite Conferences

How new products and methods in the field of industrial cleaning and allied procedures are helping to lower production costs will be the theme of four regional technical-sales conferences held by Oakite Products, Inc.

Two conferences were held in September 8-10, one in Chicago and the other in St. Louis. A third early in October was held in New York. A series of lectures and round-table discussions on the new materials which have emerged from the Oakite chemical laboratory during the past year were featured and several divisions participated in a resume of methods of applying the new chemical materials in industry.

A fourth conference is scheduled November 17-18 at the St. Francis Hotel, San Francisco.

Ajax Steam Specialty Is Sold to Strong Manufacturing

Purchase of the Steam Specialty Division of Ajax Iron Works by Strong Steam Specialty Manufacturing Company, subsidiary of Strong, Carlisle and Hammond Company of Cleveland, has been announced by J. H. Castor, general manager of Ajax Iron Works.

This Ajax Division manufactured the Strong line of steam traps and other engineering specialties exclusively for the Cleveland company, which has been marketing nationally for 40 years.

The change will enable Ajax Iron

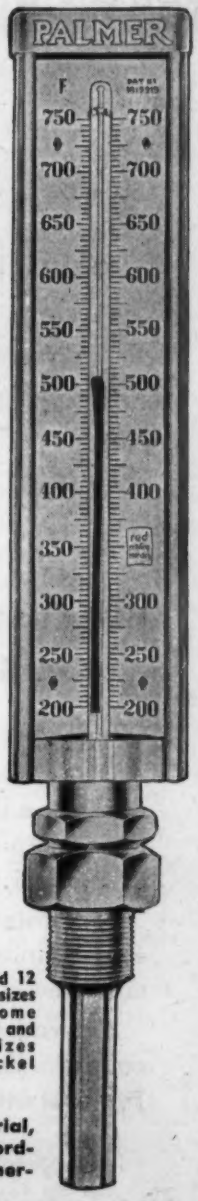
SEE red reading mercury THERMOMETERS MADE

a quick trip . . . via penny post-card-

• No matter where you are . . . New York or Kokomo . . . San Francisco or Salem . . . you can tour the modern Palmer Thermometer plant for the cost of a penny postcard . . . spend five minutes or a half-hour.

• Through the colorful pages of a new fully illustrated brochure, get a first hand story of the manufacture of quality thermometers. Observe the fascinating art of making glass tubing and other operations to final inspection and shipment of finished products. You'll see the painstaking care, never-ending testing and research which result in Palmer leadership . . . the finest in temperature indicating and recording instruments.

• The latch string is out . . . send for "The Story of Palmer Thermometers" . . . yours for the asking!



In 7, 9, and 12 inch case sizes with chrome finish; in 4 and 6 inch sizes with nickel finish.

PALMER THERMOMETERS INC.

Mfrs. of Industrial, Laboratory, Recording and Dial Thermometers.

2513 NORWOOD AVE., CINCINNATI 12, OHIO

CANADIAN PLANT: KING AND GEORGE STS., TORONTO 2

Works to concentrate upon Ajax gas engines, together with the company's regular steam engine manufacture. New shops, assembly and warehouse facilities, and an enlarged foundry, are practically completed.

Ajax expects to continue to furnish castings to Strong, Carlisle and Hammond.

Harry Krone, superintendent of the Ajax Specialty Division, will continue with the new owners in charge of manufacturing.

Chase Advertising Manager

Edward J. Malvey has been promoted to the position of advertising manager of Chase Brass & Copper Company. A native of New Haven, Malvey became associated with Chase in 1924 when he relinquished a position in the advertising department of the Winchester Repeating Arms Company.

Chicago Metal Hose Buys Fort Dearborn Manufacturing

Chicago Metal Hose Corporation of Maywood and Elgin, Ill., has purchased all the capital stock of Fort Dearborn Manufacturing Company, Sterling, Ill., which will be operated as a wholly owned subsidiary and continue its services in the field of production machining and as engineers and builders of special machinery, tools, dies and fixtures.

Chicago Metal's new program of tooling has been completed and production space will be made available at Fort Dearborn's plant where rehabilitation of buildings already has been started.

Sliter Named Assistant

Charles S. Sliter has been appointed assistant general sales manager for the Kellogg Division of the American Brake Shoe Company. With the company since 1940, Sliter will be located at the main plant in Rochester, N. Y. Kellogg's principal products are air compressors and paint spray equipment.

New ACS Sales Manager

Announcement is made by American Car and Foundry Company that Henry V. Bootes, formerly sales agent for the company, has been appointed district sales manager, New York sales district. He will continue to make his headquarters in New York. Bootes previously was district manager of The Ohio Injector Company. During World War II he saw combat duty in the South Pacific area where he served as major in the Marine Corps.

Bootes

Honeywell in Switzerland

Organization of a new subsidiary company in Switzerland has been announced by Minneapolis-Honeywell Regulator Company. Named Honeywell A. G., the new company will handle sales and service of the complete line of Honeywell controls as well as all of the industrial recording and controlling devices made by the Brown Instrument Company.

Charles B. Meech, transferred to Zurich as manager of the subsidiary company, joined Honeywell in 1936, but was in the Army from 1941 to 1946. Leo deBruyn, a member of Honeywell's international division, will assist Meech.

Monsanto Appointment

Chester L. Jones, Jr., has been appointed sales manager of the protective coatings department of Monsanto Chemical Company, Merrimac Division, Everett, Massachusetts. Until his promotion he was manager of the product development department of the plastics division, Springfield, Massachusetts.

After graduation from Yale University in 1936 he joined Resinox Corporation as a research chemist. When this concern became a part of the Monsanto organization in 1939 he continued as a member of the staff in research and sales development activity.

Turner Forms Company

Dan O. Turner has formed Turner Clay Products Company, 4517 Rossville Boulevard, Chattanooga, Tenn., and will handle equipment manufactured by George P. Reintjes Company, Kansas City, Mo. Turner has had a number of years experience especially in the South selling refractories and servicing of heat inclosures for boilers and furnaces.

Advertising Manager Named

William F. Weimer, for the past several years assistant advertising manager of Rockwell Manufacturing Company, Pittsburgh, has been named advertising manager of the company's Pittsburgh Equitable Meter Division.

He will have charge of the advertising

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BECAUSE FLUID PRESSURE
NOT GLAND PRESSURE FORMS THE SEAL

UNLIKE ORDINARY ROD and plunger packings, J-M Sea Rings have tapered lips that seal on the work stroke, release on the return. Not depending on gland pressure for their leakproof seal, they last longer, reduce friction on rod or plunger.

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JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

program for Pittsburgh Equitable's lines of water, gasoline, oil and gas meters, gas regulators, etc. He will also continue to assist with the administration of Rockwell's over-all advertising program.

Oil Well Supply Changes

Appointment of T. P. Drummond as manager of refinery and pipe line sales for Oil Well Supply Company's Gulf Coast Division was announced late last month.

Appointments also announced were J. E. Shoemake, Houston, and T. J. Love, Beaumont, Texas, as district engineers, refinery pipe line sales; and the transfer of R. L. Humphrey, division tubular representative, from New Orleans to the division office at Houston.

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916 S. PETERS STREET NEW ORLEANS, LA.

Quaker Oats Company Opens Office in New York

An Eastern sales office in the Whitehall Building, 17 Battery Place, New York, has been opened by the Chemicals Department of Quaker Oats Company, Chicago.

Miss Boland

Miss Adelia C. Boland, formerly in the Chicago office, will be the Chemicals Department representative in New York. This office will facilitate service for Eastern users and prospective users of furfural and other furan chemicals manufactured by Quaker Oats.

Quaker Oats Names Griffin

Griffin Chemical Company, 1000 Sixteenth Street, San Francisco, has been appointed as the agent in the San Francisco Bay area and all of Northern California for the chemicals department of The Quaker Oats Company, Chicago. Griffin will supply the regular line of furan chemicals manufactured by Quaker Oats, including furfural, furfuryl alcohol, tetrahydrofurfuryl alcohol and hydrofuramide.

Hose Production Resumed

Hewitt Rubber Division, Hewitt-Robins, Inc., Buffalo, N. Y., has announced first postwar production of its top brand Maltese Cross fire and chemical hose.

J. H. Hayden, vice president in charge of sales, said the lifting of government restrictions and the availability of special long staple cotton necessary to produce the high tensile duck has enabled Hewitt to reinstate this brand of fire and chemical hose which is well known in oil refineries and acid plants.

Hamilton Rubber Branch

A branch office and warehouse has been opened at 2017-19 Preston Avenue, Houston, by the Hamilton Rubber Manufacturing Corporation, manufacturers of industrial rubber products in Trenton, N. J. W. A. Olivier, recently appointed general manager of Hamilton's southern division and connected with many industries in this area for the past 28 years, is in charge. Lex O. Carmichael is assistant branch manager.

Koonce Joins Jefferson

Samuel D. Koonce, formerly of the research division of Distillation Products, Inc., has joined the sales department of Jefferson Chemical Company, Inc., New York, N. Y. Dr. Koonce will be engaged in market research and in liaison work between the sales department and the technical and research department of Jefferson.

Hill to Milwaukee

David B. Hill has been appointed district field engineer in the Atlanta office of Chain Belt Company, Milwaukee, Wis. Previously he had been an application engineer in the company's conveyor division at Milwaukee.

Simplified Cleaning of Your Stainless Steel Filter Screens

YOU can easily restore clogged stainless steel filter screens to efficient operation with built-for-the-job Oakite materials. Here's the widely-used Oakite technique for removing scale, crude oil, tar and sand obstructions from filter mesh:

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First soak screens in recommended Oakite degreasing solution. Rinse and immerse screens in safe Oakite acidic detergent; then neutralize and thoroughly rinse. Vigorous detergency of Oakite materials quickly and safely loosens deosits — thus reduces downtime and prolongs life of filter screens.

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Filter screen cleaning is only one of 88 production-maintenance cleaning operations outlined in the Oakite Petroleum Digest. Included, too, is detailed data on cleaning lube oil coolers; descaling jackets of water cooled air compressors; desliming coils of evaporative condensers — and many other jobs in which Oakite cleaning materials and methods can save you hours and dollars. Send for your copy, now.

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Clark Bros. Company Lists Personnel Changes

T. Fred Hudgins has resigned as export manager of Clark Bros. Company's New York office, 122 East 42nd Street, to found his own business in Dallas.

R. R. McCartney while retaining his post as Clark Bros. district manager, will assume Hudgins' duties as export manager. Avery G. Van Campen, who for two years headed the technical service department in the New York office, will be the sales engineer. Robert Spears, for a number of years in the technical service department in the home office at Olean, N. Y., who was recently transferred to the technical service department of the New York office, will take over Van Campen's post as head of that department.

New Grinnell Building in Long Beach

Grinnell Branch Warehouse and Sales Office

GRINNELL Company has opened a branch warehouse and sales office in Long Beach, Calif.

The new building is located at 1360 West Pacific Coast Highway (State Highway 101), strategically situated to serve the harbor area comprising Long Beach, Wilmington and San Pedro as well as the oil fields and refinery district.

Cook

W. F. (Bill) Cook, sales engineer at the company's Los Angeles branch since 1938, has been appointed branch manager. A graduate of the University of Michigan, Cook has had 20 years of experience with American Radiator and Standard Sanitary Corporation and Grinnell Company.

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U. S. Steel of Delaware Names Advertising Head

Appointment of G. Reed Schreiner as director of advertising, United States Steel Corporation of Delaware, to succeed Charles R. Moffatt, who retired September 30, has been announced.

A life-long resident of Mt. Lebanon, Pa., Schreiner began 28 years of service in advertising departments of U. S. Steel subsidiaries when he was employed by Carnegie Steel Company in 1919.

Hooker Adds to Staff

John M. Glaze has been transferred from Niagara Falls to the New York sales office of the Hooker Electrochemical Company.

A graduate chemist of Dartmouth, Glaze joined Hooker in 1942 as a research process foreman. His territory will include portions of the metropolitan area in both New York and northern New Jersey.

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Construction Engineers with experience in construction of petroleum refineries. State education, qualifications, experience, salary requirements, and date available. Address: Box 9-R, c/o Petroleum Refiner, Houston 1, Texas.

Construction Engineers with experience in construction of petroleum refineries and qualified to take responsible charge of large refinery construction projects. State education, qualifications, experience, salary requirements, and date available. Address: Box 8 R, c/o Petroleum Refiner, Houston 1, Texas.

GRADUATE ENGINEER and designer with refinery experience can handle additional exclusive accounts as manufacturer's agent. Successful record and favorable acquaintances among buyers, engineers, architects and contractors in Ohio and Northwestern Pa. Address: Box 16-R, c/o Petroleum Refiner, Houston, Texas.

ENGINEERS—Stanolind Oil and Gas Company, P. O. Box 591, Tulsa, Oklahoma, has opening for graduate chemical or mechanical engineer with two or more years experience in gasoline or recycling operations. Address: Box 206-R, c/o Petroleum Refiner, Houston, Texas.

CHIEF ENGINEER Wanted

Chief Engineer for well known established firm of Engineers & Constructors. Prefer man with 15 to 20 years of mechanical and process experience in Petroleum, Refining, Chemical and Power to organize and direct engineering work with complete responsibility. Excellent salary and bonus arrangement. Location—Midwest. Address: Box 15-R, c/o Petroleum Refiner, Houston, Texas.

Lindvall Named to Board

Dr. Fred C. Lindvall has been named to the board of directors of Consolidated Engineering Corporation, Pasadena, Calif.

Lindvall

Dr. Lindvall received his Ph. D. in Electrical Engineering in 1928 from California Institute of Technology. He is professor of electrical and mechanical engineering and chairman of the division of civil and mechanical engineering and aeronautics at California Institute of Technology.

During the war, Dr. Lindvall was head of one of the sections under the big contract with OSRD at the University.

SKF Industries Foremen Attend Chicago Tool Show

SKF Industries, Inc., Philadelphia, sent 23 of its top factory supervisory employes to the National Machine Tool Show in Chicago last month, this as "a supplement to a year-round course in which all SKF superintendents and foremen study the operations of the entire company."

SKF foremen, it has been announced, will be responsible for determining specifications and actually ordering much of the new machinery and equipment in the company's current $4 million expansion and modernization program.

The group going to Chicago included superintendents of the plants at Philadelphia and Shippensburg, Pa., and Hornell, N. Y., in addition to foremen and production design engineers.

Charles Sliter Promoted

Charles S. Sliter has been appointed assistant general sales manager for the Kellogg Division of American Brake Shoe Company. Formerly sales promotion manager, Sliter has served in various sales capacities with Kellogg since first joining the Brake Shoe Company in 1940. He will continue to direct promotional and advertising activities of the division and will be located at the main plant in Rochester, N. Y.

Ross Names Representative

Chain Gear, Inc. has been named Washington state representative for the sales engineering of heat exchange equipment, manufactured by Ross Heater & Manufacturing Company, Inc., Buffalo 13, N. Y.

Offices of Chain Gear are at 820 First Avenue, South, Seattle 4, Wash. F. H. Draper is president, N. T. Matson, vice president and J. D. Danberg, secretary.

Claiborne With Vanadium

Thomas A. Claiborne has joined Vanadium Corporation of America, engineering sales department, and will cover the petroleum production and refining fields from his headquarters in Houston.

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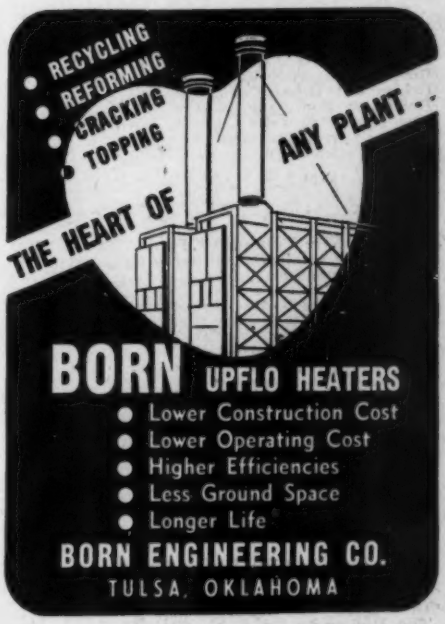

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